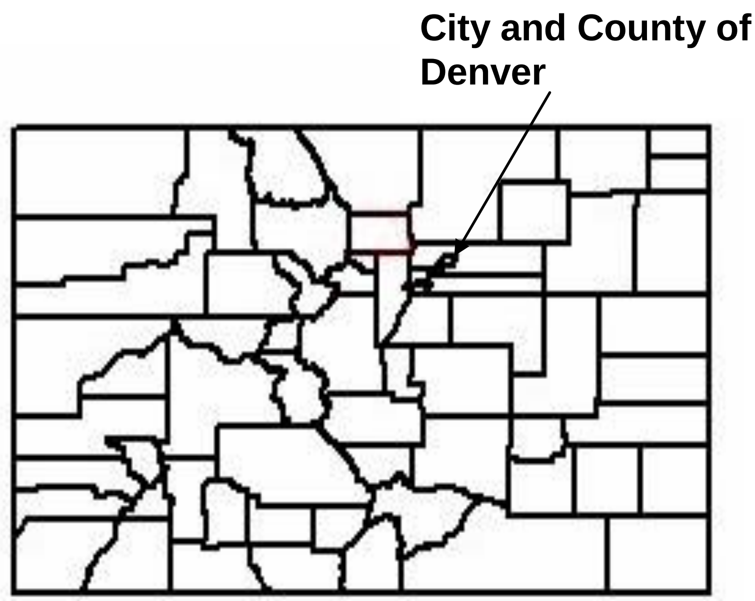
FLOOD INSURANCE STUDY

VOLUME 1 OF 2

CITY AND COUNTY OF DENVER, COLORADO



PRELIMINARY
03/10/2016

Notice
This preliminary FIS report includes only revised Flood Profiles and Floodway Data tables. See "Notice to Flood Insurance Study Users" page for additional details.

Federal Emergency Management Agency
FLOOD INSURANCE STUDY NUMBER
080046V001C

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this Flood Insurance Study may be revised and republished at any time. In addition, part of this Flood Insurance Study may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study components.

This FIS report was revised on (add new eff date). Users should refer to Section 10.0, Revisions Description, for further information. Section 10.0 is intended to present the most up-to-date information for specific portions of this FIS report. therefore, users of this FIS report should be aware that the information presented in Section 10.0 supersedes information in Sections 1.0 through 9.0 of this FIS report.

Initial FIS Report Effective Date: April 15, 1986

Revised FIS Report Effective Dates: September 28, 1990
August 3, 1992
April 16, 1993
March 4, 1996
September 7, 1998
November 17, 2005
November 20, 2013

The Preliminary FIS report does not include unrevised Floodway Data tables or unrevised Flood Profiles. These unrevised components will appear in the final FIS report.

(This page intentionally left blank)

TABLE OF CONTENTS

Volume 1

TABLE OF CONTENTS - continued

Page

FIGURES

TABLES

APPENDIX A

Volume 2

EXHIBITS

Exhibit 2 -	Flood Insurance Rate Map Index (Published Separately)
	Flood Insurance Rate Map (Published Separately)

FLOOD INSURANCE STUDY
CITY AND COUNTY OF DENVER, COLORADO

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study/Flood Insurance Rate Map for the City and County of Denver, Colorado. This information will be used by the City and County of Denver to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Gingery Associates, Inc., for the Federal Emergency Management Agency (FEMA), under Contract No. 11-4549. This study was completed in June 1981.

Revised hydraulic analyses for Clear Creek, Bear Creek, and Weir Gulch were performed by Dames & Moore for FEMA under Contract No. C-0542.

Revised hydraulic analyses for the South Platte River were provided for FEMA by the Urban Drainage and Flood Control District (UDFCD) and were completed in September 1987.

Revised hydraulic analyses for Weir Gulch, Weir Gulch Dakota Avenue Tributary, and Coon Creek were performed by Love and Associates, Inc., and Drexel Barrell Engineers/Surveyors, Inc., and completed in June 1989.

Revised hydraulic analyses for Marston Lake North were performed by WRC Engineering, Inc., and Rocky Mountain Consultants, Inc. (RMC), and completed in October 1989.

1.3 Coordination

Streams requiring detailed and approximate study were identified at a meeting attended by representatives of the study contractor, FEMA, the Colorado Water Conservation Board (CWCB), the UDFCD, and officials of the City and County of Denver on June 1, 1977. During the course of work done by the study contractor, hydrologic and other flood information was coordinated with FEMA, the U.S. Army Corps of Engineers (COE), the CWCB, the UDFCD, and the City and County of Denver.

Base map information on this FIRM was provided in digital format by the City and County of Denver, Department of Public Works Geographic Information Systems (GIS) Division dated 2015.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City and County of Denver, Colorado. The area of study is shown on the Vicinity Map (Figure 1).

The City of Glendale and unincorporated areas of Arapahoe County, Adams County, and Jefferson County located within Denver are not included in this study.

The limits of detailed and approximate studies were determined by FEMA with community and study contractor consultation at the meeting on June 1, 1977.

The flooding sources studied by detailed methods are shown in Table 1.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 1986.

Detailed hydraulic reanalysis of the South Platte River, conducted by Wright Water Engineers, Inc., under contract to the UDFCD, were submitted to FEMA in August 1986 and September 1987.

Due to current construction of channel improvements, flooding determined for Westerly Creek has been presented in this study as approximate.

Coon Creek, First Creek, and First Creek Tributary T were originally studied in detail by the study contractor. The study contractor's analyses were based on basin development conditions existing along Coon Creek in 1978; and along First Creek and First Creek Tributary T in 1977. Due to increased development within these stream basins, Coon Creek, First Creek, and First Creek Tributary T analyses have been revised to reflect projected fully developed basin conditions. Flooding determined for these streams has been presented in this study as approximate until such time as development in these basins increases to the projected conditions.

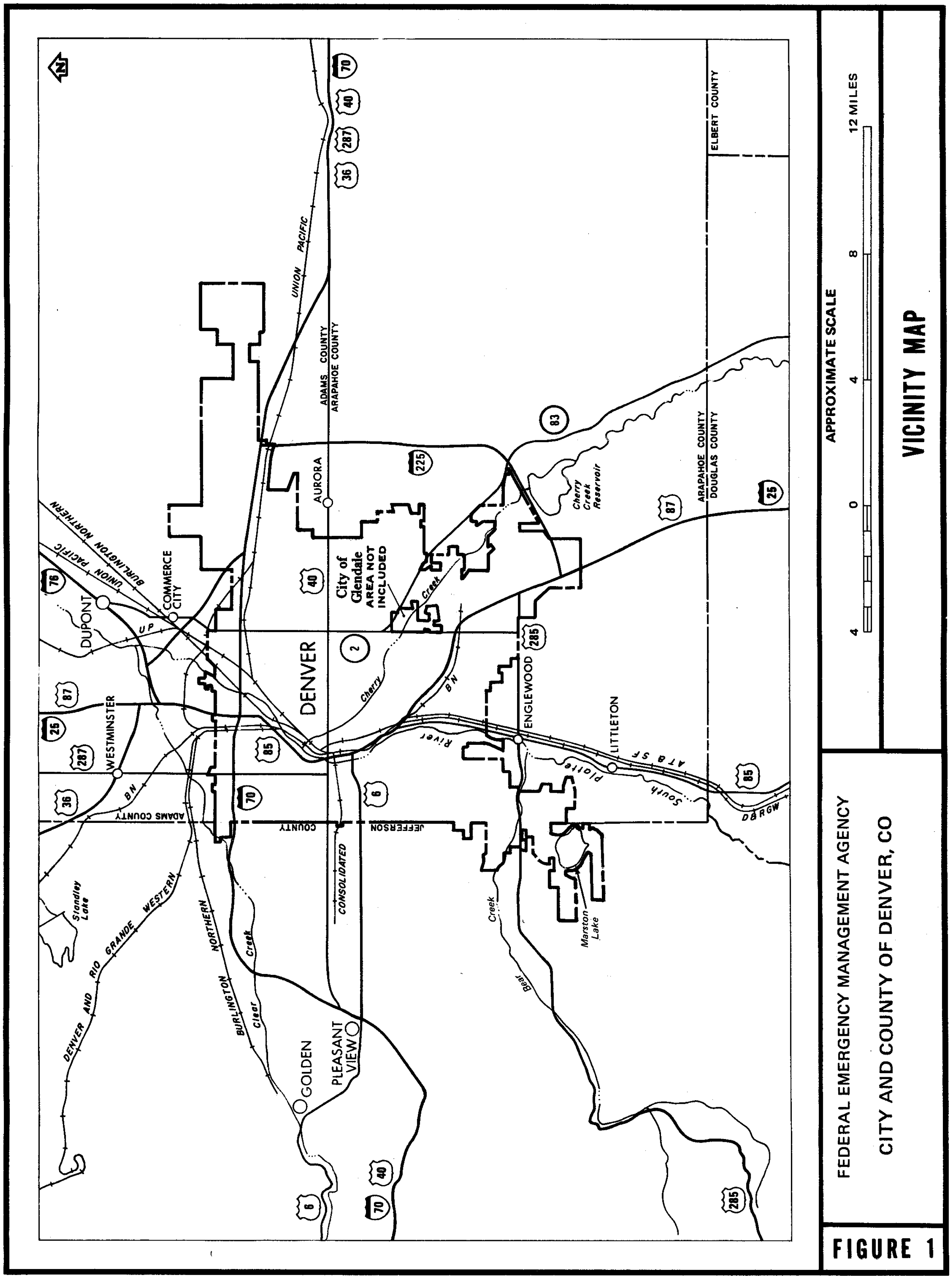

FEDERAL EMERGENCY MANAGEMENT AGENCY
CITY AND COUNTY OF DENVER, CO
VICINITY MAP
APPROXIMATE SCALE
4 0 4 8 12 MILES
DENVER
AURORA
City of Glendale AREA NOT INCLUDED
COMMERCE CITY
DUPONT
WESTMINSTER
ENGLEWOOD
LITTLETON
GOLDEN
PLEASANT VIEW
ADAMS COUNTY
ARAPAHOE COUNTY
DOUGLAS COUNTY
ELBERT COUNTY
JEFFERSON COUNTY
CONSOLIDATED
UNION PACIFIC
BURLINGTON NORTHERN
DENVER AND RIO GRANDE WESTERN
South Platte River
Cherry Creek
Cherry Creek Reservoir
Clear Creek
Bear Creek
Marston Lake
Standley Lake
FIGURE 1

Table 1. Flooding Sources Studied by Detailed Methods

Stream	Length and Location of Study Area
South Platte River	Approximately 11.1 miles, from the southern corporate limits at West Dartmouth Avenue to the northern corporate limits.
Clear Creek	Approximately 0.2 mile, at West 52nd Avenue in the northwest portion of the city.
Bear Creek	Approximately 3.0 miles, from the corporate limits at South Wadsworth Boulevard (State Highway 121) to the corporate limits at South Lowell Boulevard.
Cherry Creek	Approximately 9.3 miles, from Interstate Highway 225 to the confluence with the South Platte River.
Westerly Creek	Approximately 2.7 miles, from Kelly Road Dam (above 11th Avenue) to the confluence with Sand Creek.
Lakewood Gulch	Approximately 2.3 miles, from the corporate limits at Sheridan Boulevard (State Highway 95) to the confluence with the South Platte River.
Lakewood Gulch Overflow	From the divergence from Lakewood Gulch to the confluence with the South Platte River.
Dry Gulch (Lakewood Gulch Tributary)	Corporate limits upstream of Sheridan Boulevard (State Highway 95) to the confluence with Lakewood Gulch.
First Avenue Tributary	Approximately 0.6 mile, from the corporate limits at Sheridan Boulevard (State Highway 95) to the confluence with Weir Gulch.
Dakota Avenue Tributary	Approximately 0.2 mile, from the corporate limits at Sheridan Boulevard (State Highway 95) to the confluence with Weir Gulch.
Sand Creek	Approximately 2.9 miles, in the northeast portion of the city through the former Stapleton International Airport.
Sand Creek Overflow	From the confluence with Sand Creek to approximately 0.4 mile upstream.

Table 1. Flooding Sources Studied by Detailed Methods, cont'd

Stream	Length and Location of Study Area
Sand Creek Smith Road Overflow	Approximately 0.7 mile, from the confluence with Sand Creek to the divergence from Sand Creek.
First Creek	Approximately 3.3 miles, downstream of Picadilly Road within the northeastern portion of the city.
First Creek Tributary T	Approximately 1.3 miles, from the corporate limits at Picadilly Road to the confluence with First Creek.
Harvard Gulch	Approximately 3.3 miles, from below South Colorado Boulevard (State Highway 2) to the confluence with the South Platte River.
Harvard Gulch Overflow	From South Downing Street (where overflows occur from Harvard Gulch) to the confluence with Harvard Gulch.
Dry Gulch (Harvard Gulch Tributary)	Approximately 0.3 mile, from below West Yale Avenue to the confluence with Harvard Gulch.
West Harvard Gulch	Approximately 1.0 mile, from South Federal Boulevard (State Highway 88) to the confluence with the South Platte River.
Goldsmith Gulch	Approximately 4.9 miles, from Belleview Avenue (State Highway 88) to the confluence with Cherry Creek.
Southmoor Park Tributary	Approximately 0.6 mile, from the detention pond above Hampden Avenue (State Highway 30) to the confluence with Goldsmith Gulch.
Sanderson Gulch	Approximately 3.4 miles, from the corporate limits at Sheridan Boulevard (State Highway 95) to the confluence with the South Platte River.
Weir Gulch	Approximately 3.5 miles, from the corporate limits at Sheridan Boulevard (State Highway 95) to the confluence with the South Platte River.

Sloans Lake Basin was studied by the study contractor using approximate methods. An approximate analysis of Marston Lake North Drainage Basin was included in this study by Dames & Moore at the request of FEMA.

Marston Lake North has been revised to reflect channel improvements, the addition of culverts and a sedimentation basin.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the City and County of Denver.

2.2 Community Description

The coextensive City and County of Denver is situated on gently rolling land 40 miles east of the Continental Divide in north central Colorado. The altitude is 5,280 feet on the steps of the State Capitol Building and is the reason for the title "Mile High City." Panoramic views of the towering ranges of the Rocky Mountains can be enjoyed from innumerable vantage points in Denver, and the vista sweeps from Pikes Peak, 75 miles southward, to Longs Peak, 65 miles northwest of the city. The population in the City and County of Denver is 600,158 according to the 2010 census.

Denver derived its name from James W. Denver, the Territorial Governor of Kansas at the time of the city's origin. In November 1858, a party of land claim "jumpers" appropriated the town site of St. Charles, located on the east bank of Cherry Creek, and established a new settlement named by them "Denver City." In April 1861, Denver City and its rival town, Auraria, consolidated under the name "Denver." When Congress authorized Colorado's entry into the Union on August 1, 1876, Denver was made the State Capital (Reference 1).

Denver is bordered by the incorporated Cities of Lakewood, Aurora, Wheat Ridge, Sheridan, Englewood, Cherry Hills Village, Littleton, Edgewater, Commerce City, Glendale, and Greenwood Village, and the incorporated Towns of Bow Mar, Lakeside, and Mountain View. Denver is also bordered by unincorporated areas of Adams, Jefferson, and Arapahoe Counties.

Denver has elevations ranging from nearly 5,200 feet to approximately 5,500 feet. With its location in the mid-latitudes in the interior of the North American continent, Denver experiences large temperature changes from summer to winter and rapid changes in weather due to storms traveling from west to east through the region. The mountains to the west effectively block atmospheric moisture originating in the Pacific Ocean and leave the area dependent on moisture from the Gulf of Mexico, which is not consistently brought to the region. Consequently, the region is dry with low amounts of precipitation that are quite variable through the year. Small amounts of water in the air are accompanied by a large percentage of sunshine and sizable temperature changes from day to night.

Large temperature changes are observed at Stapleton International Airport during the year, where the monthly average varies from 29.7°F in January to 72.9°F in July. The mean maximum varies from 43.4°F in January to 87.40F in July, while the mean minimum varies from 16.0°F in January to 58.3°F in July, which is indicative of the extent of temperature change from day to night.

Average annual precipitation of 15.2 inches at Stapleton International Airport was determined from data taken over a 25-year period, while 12.4 inches was observed downtown over a 23-year duration. Both stations show a distinct maximum in spring and summer, with a minimum in the winter season. Spring and summer bring much more frequent movement of air from the south and more solar radiation to produce convective showers. Average annual snowfall measurements are 66 inches at the airport and 56 inches in the central part of the city.

Average winds do not change much throughout the year. The prevailing direction is from the south in every month, and speeds vary from 8.2 miles per hour (mph) in late summer and early fall to 10.4 mph in April (Reference 1).

The soils in the Denver area are generally deep, well-drained, clayey soils that are neutral or mildly alkaline (Reference 2). There are significant sand and gravel deposits along the major streams in the city. These include deposits along the South Platte River, Bear Creek, and Clear Creek. The basins of Sand Creek and Cherry Creek contain fine sand, but little gravel (Reference 1).

The major stream in the Denver area is the South Platte River. It flows 380 miles from its headwaters at the Continental Divide in Park County to its confluence with the North Platte River at North Platte, Nebraska, where the drainage area is approximately 24,300 square miles. The drainage area of the South Platte River in Denver is approximately 3,800 square miles.

The major tributaries to the South Platte River in the Denver area are Cherry Creek (drainage area 410 square miles), Sand Creek (drainage area 189 square miles at Quebec Street), Clear Creek (drainage area 575 square miles), and Bear Creek (drainage area 261 square miles at the mouth).

In most cases, present-day conditions have reached or are approaching full urbanization for major drainage basins in the Denver area. The exceptions include Coon Creek, First Creek, and First Creek Tributary T. Coon Creek is a smaller basin where a large amount of residential development is occurring. Clear Creek, Sand Creek, First Creek, and First Creek Tributary T are larger basins with most of their development at the lower end of the basins near the confluence with the South Platte River. The Bear Creek floodplain has moderate residential development, with some open space and industrial commercial areas. The other major drainageways are fully urbanized in the Denver area and are bounded by residential development with the exception of the South Platte River and Cherry Creek, which also flow through commercial and industrial areas.

2.3 Principal Flood Problems

Past flooding along most of the streams in Denver has been well documented in several reports by the COE and the UDFCD.

Large floods have been reported on the South Platte River in 1844, 1864, 1867, 1876, 1894, 1921, 1933, 1942, 1965, and 1973. The Largest and most damaging of these occurred June 16 and 17, 1965, when a discharge of 40,300 cubic feet per second (cfs) was computed at U.S. Geological Survey stream gage No. 06714000 near the 19th Street Bridge in Denver. Flooding occurred throughout the South Platte River Basin with six persons drowned, two other deaths caused by flood-related activities, and estimated damages of $500 million, of which $300 million occurred in the Denver area (References 3-7).

Past floods on Clear Creek in the Denver area have been infrequent and usually not severe in the lower reaches. The major flooding has occurred upstream from Denver, including the City of Golden in 1888 (8,700 cfs) and 1956 (5,250 cfs), and Derby in 1965 (5,070 cfs) (Reference 8).

Flooding has occurred along Bear Creek in 1876, 1894, 1896, 1957, 1965, and 1969. The 1896 flood was the largest experienced, with 27 lives lost and severe property damage reported from the Town of Evergreen to the mouth. The discharge at the Town of Morrison gaging station was 8,600 cfs (Reference 9).

Prior to the construction of Cherry Creek Dam, major floods occurred on Cherry Creek in 1864, 1885, 1912, and 1933. Both the 1912 and 1933 floods were reported to have resulted in damages of approximately $1 million (Reference 10). Construction of Cherry Creek Dam was completed in 1950, and the dam is estimated to have prevented considerable damage during the flood of June 1965.

From 1942 to the present, there have been at least 14 years with major flooding events from Cherry Creek, during which flooding of premises and impedance of traffic occurred. Flood-causing rainfall in these years produced overland inundation of homes and streets to depths of as much as 4.5 feet. Floodflows in this area (north of Lowry Air Force Base) for these storm events were in the range of 300 to 600 cfs. From 1942 through the early 1960s, flooding problems were confined to areas downstream of Lowry Air Force Base. Since approximately 1965, rainfall flood events have begun to occur in the upper watershed as a direct result of the increasing density of development (Reference 11).

For Dry Gulch (Lakewood Gulch Tributary), there are no accurate records of flood-history available; however, it is well known that there have been numerous instances of minor damage occurring at several locations along the stream (Reference 12).

Prior to 1965, Harvard Gulch experienced regular flooding due to summer thunderstorms. Considerable encroachment of the floodplain and channel occurred because of the lack of city zoning designed to prevent such encroachment. The infringement on the channel was so complete that the defined channel ended approximately 0.5 mile from the South Platte River. Floodwater, searching out a route to the river, flowed down South Broadway, an important neighborhood business street (Reference 13). The Harvard Gulch Flood Control Project, completed in 1966, was designed for the 10-year flood and has alleviated these problems. The largest flood event since the completion of this project occurred on June 8, 1969. Three gages in this basin recorded between 1.2 inches and 2.6 inches of rainfall in a 1-hour period. The runoff hydrograph for this event was recorded at the gaging station near South Logan Street. The hydrograph peak was approximately 1,600 cfs, and this flow was confined within the drainage improvements (Reference 14).

For Goldsmith Gulch and Southmoor Park Tributary, little information is available on past flooding because development was sparse in these areas. Flooding indicative of what might be expected under present conditions occurred on May 5 and 6, 1973, when the capacities of the crossings at Dartmouth and Yale Avenues were exceeded by what was estimated to be a 5- to 10-year event (References 15 and 16).

Major floods have not occurred on Sanderson Gulch in the last 20 years and prior to that time there are no accurate records available (References 17 and 18).

For Weir Gulch, First Avenue Tributary, and Dakota Avenue Tributary, historical information on flooding is scarce. A few instances of flooding resulting in minor basement damage and some channel and bridge damage have been reported (References 19 and 20).

There were major floods on Sand Creek in 1896, 1912, 1917, 1921, 1933, 1938, 1948, 1957, and 1965. Because the basin was essentially undeveloped up to approximately 1940, flood damages are not well documented. The 1948 flood had a discharge at the mouth estimated at 10,500 cfs. Resulting damages throughout the basin were over $130,000. Near Stapleton International Airport the 1957 flood had a discharge estimated to be 25,000 cfs. Total damages throughout the basin were in excess of $330,000. The 1965 flood resulted in damages of $2,517,000 along Sand Creek. The discharge below Toll Gate Creek (located upstream in the City of Aurora) was 18,900 cfs (Reference 21).

Little definitive data on past flooding on First Creek and First Creek Tributary T are available due to the sparse development in the area. Until recently, the First Creek and First Creek Tributary T floodplains were entirely agricultural.

No specific information regarding historic flood magnitudes or extent of flooding and damages is available for Coon Creek, Lakewood Gulch, West Harvard Gulch, and Dry Gulch (Harvard Gulch Tributary).

2.4 Flood Protection Measures

There are numerous dams, reservoirs, and channel improvements within the South Platte River Basin. Many of these flood protection measures affect flood peaks on the flooding sources that flow through Denver.

In addition to an active floodplain management program, the major flood protection measures, by basin, are listed below:

South Platte River

The Chatfield Dam and Lake along the South Platte River were authorized for construction by the 1950 Flood Control Act. The dam is located on the South Platte River just downstream from the mouth of Plum Creek, south of Denver. The reservoir has a storage capacity of 385,000 acre-feet, including 215,000 acre-feet for flood storage and 20,000 acre-feet for sediment control. The project provides a high degree of protection for metropolitan Denver and for extensive agricultural lands downstream (Reference 4).

Clear Creek

There are 11 major reservoirs in the lower Clear Creek basin, 3 of which, Ralston Reservoir, Maple Grove Reservoir, and Leyden Lake, are on-stream and provide some residual flood control effects downstream from each site. None of these reservoirs has a specific flood control function.

Ralston Reservoir, located west of Denver and northwest of the City of Golden, was built in 1938 by the City and County of Denver. It receives water from Ralston and South Boulder Creeks and is used for municipal water supply. The outlet works deliver water to the Moffat Treatment Plant and have the capability of forcing the natural inflow back into Ralston Creek. Although Ralston Reservoir is not operated for flood control purposes, there is approximately 2,400 acre-feet of storage available between the primary spillway crest at elevation 6,046.0 feet and the top of the dam at elevation 6,060.0 feet. This storage provides incidental flood control.

Maple Grove Reservoir, which is located on Lena Gulch in the City of Lakewood, is owned by Consolidated Mutual Water Company and is used for municipal water-supply storage. The reservoir provides some attenuation of flood peaks. Approximately 452 acre-feet of storage are available between the crest of the inlet at elevation 5520.0 feet and the top of the fabridam at elevation 5531.0 feet.

Leyden Lake is an irrigation water-storage reservoir on Leyden Creek northwest of Denver. There are approximately 550 acre-feet of uncontrolled storage between the spillway crest at 5,612 feet and the crest of the dam at elevation 5,620 feet (References 22 and 23).

Bear Creek

The completion of the Bear Creek Dam just downstream of the Town of Morrison has greatly affected the peak discharges of Bear Creek. Designed by the COE, the dam provides a flood control reservoir that intercepts flows from areas in the upper and middle parts of the basin. At the Bear Creek Reservoir, peak flows from the 100-year event have been reduced from 30,000 cfs to approximately 1,000 cfs through storage in the reservoir. There has been some straightening and enlargement of the channel downstream of the dam to reduce flooding in the lower, more developed areas of Bear Creek (References 9 and 24).

Cherry Creek

Cherry Creek Dam and Cherry Creek Reservoir were constructed by the COE, Omaha District, in 1953. The project, located immediately upstream of Denver, was constructed at a Federal cost of approximately $14.7 million and provides protection for Denver from flash floods on Cherry Creek. The reservoir has a flood-storage capacity of 79,960 acre-feet. During the June 1965 flood of record, the project prevented an estimated $130 million in flood damages. During the 1973 flood season, it prevented an additional $27 million in damages (Reference 4).

Retaining walls have been constructed along the Cherry Creek channel downstream of First Avenue to the confluence with the South Platte River. Portions of Cherry Creek, between First Avenue and the South Platte River, and in the vicinity of South Monaco Street Parkway, have been improved and recently rehabilitated to carry much of the 100-year flood flow within the channel banks. Earthen berms have been constructed south along Cherry Creek between South Holly Street and upstream of South Monaco Street Parkway, which have minimal effect on the 100- and 500-year flood.

Westerly Creek

The Kelly Road Dam on Westerly Creek was constructed by the COE in 1954 (Reference 4) to control storm runoff; however, the urban development upstream has lowered the protection level. A recent rehabilitation project has restored somewhat the structure's ability to attenuate flood peaks. Channel improvements are underway downstream of Kelly Road Dam. When completed, they will further reduce the flood hazard between 11th Avenue and Stapleton International Airport.

Coon Creek

The Coon Creek basin is undergoing rapid development, with more proposed for the future. The emphasis is on channel improvements that will confine the 100-year flood to the channel. Individual developers are constructing the channel improvements as new subdivisions are built adjacent to the existing channel. Improvements have been made to the Coon Creek Drainageway to provide for development of a shopping center. The channel improvements provide conveyance of the 100-year flood from State Highway 121 to a point approximately 1,850 feet upstream (Reference 25).

Harvard Gulch, West Harvard Gulch. Dry Gulch (Harvard Gulch Tributary)

Several drainage improvement projects have been constructed in the Harvard and West Harvard Gulch basins over the last 15 years. The more extensive improvements were made on Harvard Gulch as part of the Harvard Gulch Flood Project, which was the result of a $2.3 million bond issue passed by Denver in 1964.

This project included an underground box culvert from South Logan Street to the South Platte River where the channel had been obliterated by development. A grass-lined channel was designed through Logan Park; this channel also serves as an inlet to a detention pond in the park.

Above Logan Park, from South Ogden Street to South Downing Street, improvements included a second box culvert. This culvert connects with a high-velocity concrete channel from South Downing Street upstream to South Race Street. Above South Race Street, improvements were made to the existing grass-lined channels. The system will safely convey floodflows slightly less than what could be expected to result from a 10-year storm event.

In addition, since 1964, several storm sewer systems have been constructed in this basin. The most extensive system is along Dry Gulch (Harvard Gulch Tributary). There, the storm sewer serves to intercept nuisance flows that would otherwise flow through residential lots where this• channel has been obliterated. The storm sewer is designed to convey the 10-year storm.

In the West Harvard Gulch basin, the main drainageway improvement is an underground conduit that extends from just above the Burlington Northern Railroad to South Zuni Street. The conduit handles West Harvard Gulch low flows, and an improved grass-lined channel above these culverts carries overflows during flood events. .The West Harvard Gulch channel in this area will pass the 100-year flood with only minor overbank flooding (Reference 14).

Goldsmith Gulch and Southmoor Park Tributary

Development has encroached on the Goldsmith Gulch floodplain, particularly through Denver where various structural improvements have been made to provide a limited degree of conveyance for floodflows.

Structural improvements along the downstream portion of Goldsmith Gulch include a berm constructed along the east edge of South Monaco Street Parkway near the confluence with Cherry Creek, and regrading of the floodplain in the vicinity of Evans Avenue. Improvements along the upstream portion of Goldsmith Gulch include the construction of the Eastman Avenue crossing of Goldsmith Gulch, and regrading within the floodplain at several locations throughout the reach.

Southmoor Park, a large, open area along Southmoor Park Tributary, serves as a detention pond that reduces flood magnitudes along the tributary and along Goldsmith Gulch (Reference 15). Additional improvements include the construction of the Eastman Avenue crossing of Southmoor Park Tributary.

Sanderson Gulch

At the upper end of the Sanderson Gulch drainage basin, in the City of Lakewood, there are two irrigation storage reservoirs that affect the discharges along Sanderson Gulch during the major flood events. They are Smith Reservoir and Kendrick

Reservoir. There are also a series of small reservoirs, lakes, and detention ponds along Sanderson Gulch upstream of Denver that offer some flood protection.

On Sanderson Gulch, an improved grass-lined channel extends from the South Platte River to South Federal Boulevard (State Highway 88). Culverts were improved at South Lipan Street, West Arkansas Avenue, and South Zuni Street. Only minor improvements were completed from South Federal Boulevard (State Highway 88) to South Sheridan Boulevard (State Highway 95) consisting primarily of small drop structures.

Improvements were made to the Bit-O-Sea Reservoir located on Sanderson Gulch immediately upstream of South Sheridan Boulevard (State Highway 95) within the City of Lakewood. The earth embankment was raised and protected to increase storage, and the spillway was improved to increase capacity for discharge of the 100-year event.

Weir Gulch

In the upper part of the Weir Gulch drainage basin, there are three irrigation storage reservoirs that affect the floodflows on Weir Gulch: Main Reservoir, Smith Reservoir, and East Reservoir, located upstream of Denver, in the City of Lakewood. There are also two lakes along Weir Gulch, Kountze Lake (also located in Lakewood) and Barnum Lake, both of which store floodwaters and protect areas downstream from flooding.

Channel improvements along Weir Gulch have been constructed from West Alameda Avenue to the confluence with the South Platte River (References 26-30). Improvements include the regrading of Barnum Lake and the construction of an additional outlet culvert under West 6th Avenue (U.S. Highway 6), designed to reduce the extent of 100- and 500-year flooding below Barnum Lake.

Channel improvements along Weir Gulch have been constructed from just downstream of West Alameda Avenue to Sheridan Boulevard. Improvements included the construction of an approximately 4,200 foot long channel designed to convey the 100-year flood, five bridges, and three drop structures, designed to convey the flows beneath the four roadways it crosses (Reference 31).

Weir Gulch Dakota Avenue Tributary

The Weir Gulch Dakota Avenue Tributary project, which extends from the confluence at Weir Gulch upstream to South Sheridan Boulevard, is comprised of a new culvert system which supplements the capacity of an existing adjacent storm sewer system (Reference 32). The culvert system was designed to convey the 100-year flood.

Sand Creek

Levees are located along Sand Creek in the vicinity of Havana Street; however, these levees have no effect on the 100- and 500-year floods.

Marston Lake North

The Marston Lake North drainageway improvements extend from Vaile Lake upstream to the corporate limits. These improvements include construction of an energy dissipation plunge pool basin and a golf cart crossing in a portion of the existing Vaile Lake; installation of two 5-foot high by 10-foot wide reinforced-concrete box culverts under Quincy Avenue; construction of a grass-lined channel from South Wadsworth Boulevard to just upstream of Quincy Avenue; the addition of two 72-inch steel pipes under Highway 121; construction of a 40-foot transition structure directly upstream of Highway 121; addition of 1,532 linear feet of 8'x7' twin barrel box culvert, and 520 feet of open channel; and construction of an 8.4 acre-feet sedimentation control basin with 85 linear feet of drainage channel which connects to the existing channel (References 33 and 34). The channel and culvert improvements convey the 100-year recurrence interval flood, with the exception of some overland flow at South Wadsworth Boulevard.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analysis

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

The hydrologic analysis for Clear Creek was performed by the COE, Omaha District (Reference 23). Their analysis was based on fully developed basin conditions. Discharge records for the Clear Creek stream gages at Golden and Derby were analyzed using methods presented in Bulletin No. 17 published by the U.S. Water Resources Council (Reference 35). The results of these analyses were used to calibrate to the following runoff models: the Massachusetts Institute of Technology Catchment Model (MITCAT) (Reference 36), and the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (Reference 37). MITCAT was used to model the 400-square-mile mountainous area upstream from Golden; the Storm Water Management Model was used to model the lower 175-square-mile plains basin. Rainfall values used in the models were obtained from the Precipitation-Frequency Atlas of the Western United States, Volume II, Colorado, published by the National Oceanic and Atmospheric Administration in 1973 (Reference 38).

The hydrologic analysis for Bear Creek was performed by the COE, Omaha District (Reference 24). The Bear Creek Dam and Reservoir intercepts flows from 239 square miles of the total 261-square-mile drainage basin. The remaining square-mile drainage area below Bear Creek Dam still has the potential of generating damaging runoff flows during a cloudburst event over the lower basin. No applicable runoff records are available through this reach because of the recent construction of the dam. Therefore, discharges for the 22-square-mile drainage area below the dam were developed by using the EPA Storm Water Management Model (Reference 37) with modifications by the Missouri River Division of the COE. These discharges were computed assuming full basin development.

Peak discharges for Cherry Creek were previously determined as part of the July I976 UDFCD Flood Hazard Area De1ineation report for Cherry Creek (Reference 10). Those discharges were computed using the EPA Storm Water Management Model (Reference 37). The Cherry Creek basin was assumed to be fully developed.

Peak discharges for Lakewood Gulch and Lakewood Gulch Overflow were previously determined as part of the 1976 UDFCD major drainageway planning report (Reference 39). Those discharges were computed using the Colorado Urban Hydrograph Procedure as outlined in the Urban Storm Drainage Criteria Manual (Reference 40). Split flows were calculated along Lakewood Gulch in the reach between Decatur Street and the South Platte River. The divergence of flows from Lakewood Gulch at Decatur Street is referred to in this study as Lakewood Gulch Overflow.

Peak discharges for Dry Gulch (Lakewood Gulch Tributary) were previously determined as part of the 1977 UDFCD Flood Hazard Area Delineation report (Reference 12). The Colorado Urban Hydrograph Procedure (Reference 40) was used to compute the 10-, 50-, and 100-year events under fully developed basin conditions. The 500-year flood peak was obtained by extrapolation from the frequency-discharge curve.

Peak discharges along Harvard Gulch, Harvard Gulch Overflow, Dry Gulch (Harvard Gulch Tributary), and West Harvard Gulch were determined as part of the 1979 UDFCD Flood Hazard Area Delineation report (Reference 14). Those discharges were computed using the Colorado Urban Hydrograph Procedure (Reference 40).

Split flows were calculated along Harvard Gulch between South Downing Street and South Logan Street. Due to the limited capacity of the box culvert between South Downing and South Ogden Streets to carry the 100-year flood, flooding occurs overland to an old channel, through a detention pond, and rejoins Harvard Gulch. These flows through Logan Park are referred to in this study as Harvard Gulch Overflow.

Dry Gulch (Harvard Gulch Tributary) consists of two 43- by 68-inch reinforced-concrete pipe culverts along the entire study reach. These culverts carry only 250 cfs of the 1,330 cfs 100-year flood event. The remaining floodwaters flow overland through a park area and continue down Pearl Street to the confluence with Harvard Gulch.

Peak discharges for Goldsmith Gulch and Southmoor Park Tributary were determined as part of the 1976 UDFCD Flood Hazard Area Delineation report (Reference 15). The 10- and 100-year discharges were computed using the Colorado Urban Hydrograph Procedure (Reference 40). The 50- and 500-year discharges were obtained by interpolation and extrapolation of the frequency-discharge curve.

Southmoor Park serves as a detention pond to reduce flows along Southmoor Park Tributary. Reduced flows are released through an intake pipe to a culvert located under the detention pond and Hampden Avenue (State Highway 30).

Peak discharges for Sanderson Gulch and Weir Gulch were determined as part of the 1972 UDFCD Major Drainageway Planning report (Reference 41). The 10-, 50-, and 100-year discharges were calculated using the Colorado Urban Hydrograph Procedure (Reference 40) for fully developed basin conditions. The 500-year discharge was extrapolated from the data. Peak discharges on Weir Gulch downstream of Barnum Lake were revised to reflect channel improvements at Barnum Lake and increased culvert capacity at West 6th Avenue (U.S. Highway 6).

Peak discharges for First Avenue Tributary and Dakota Avenue Tributary were determined as part of the 1977 UDFCD Flood Hazard Area Delineation report (Reference 20). Those discharges were calculated in accordance with the Colorado Urban Hydrograph Procedure (Reference 40) assuming fully developed basin conditions. The subbasin hydrographs were routed downstream. The Puls Method was used to calculate discharges at locations where storage had a significant effect.

Peak discharges for Sand Creek were determined as part of the 1977 UDFCD Flood Hazard Area Delineation report (Reference 42). The hydrologic analysis was based on the development of a surface runoff model of the Sand Creek basin using the runoff block of the EPA Storm Water Management Model (Reference 37). Discharge hydrographs developed from the model were then routed along the main stem of Sand Creek by use of an unsteady flow-routing procedure developed by James A. Harder and modified by the Missouri River Division of the COE. Discharge probability relationships were developed by inserting precipitation-frequency values (Reference 43). The discharges were calculated for fully developed basin conditions.

Peak discharges for the South Platte River were determined as part of the September 1985 UDFCD Flood Hazard Area Delineation report (Reference 44). Peak-frequency values for the South Platte River were taken from the May 1983 Hydrologic Study report prepared by Merrick and Company under contract to the UDFCD (Reference 45).

Peak discharge-drainage area relationships for all streams studied by detailed methods are shown in Table 2.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments where a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Insurance Rate Map.

Table 2. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Clear Creek					
At West 52nd Avenue	575.0	3,710	9,750	14,520	31,000
Bear Creek					
At South Sheridan Boulevard (State Highway 95)	__[1]	4,120	6,710	7,910	11,800
Cherry Creek					
Upstream of Confluence With Goldsmith Gulch	7.0	1,550	3,000	3,950	6,700
At Mouth	25.2	4,100	7,500	9,700	13,300
Lakewood Gulch					
At Mouth	16.0	5,130	5,300	6,010	7,900
Lakewood Gulch Overflow					
Downstream of Divergence from Lakewood Gulch	__[1]	1,100	2,700	3,200	5,750
Dry Gulch (Lakewood Gulch Tributary)					
At Mouth	3.7	1,520	1,980	2,180	2,600
Harvard Gulch					
At South Race Street	3.8	2,400	3,000	3,250	3,900
At South Logan Street	6.3	3,360	4,400	4,860	5,900
Harvard Gulch Overflow					
Upstream of South Ogden Street	__[1]	720	1,200	1,600	1,900
Dry Gulch (Harvard Gulch Tributary)					
At Mouth	1.8	650	950	1,080	1,400
West Harvard Gulch					
At South Federal Boulevard (State Highway 88)	0.6	700	900	1,000	1,200
At Mouth	1.4	1,300	1,630	1,785	2,100
Goldsmith Gulch					
At Belleview Avenue	2.6	605	1,251	1,760	2,337
At Mouth	8.0	1,493	1,973	2,200	2,200

[1] Data Not Available

Table 2. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Southmoor Park Tributary					
At Mouth	1.4	500	500	500	930
Sanderson Gulch					
At South Sheridan Boulevard (State Highway 95)	5.3	1,030	1,400	1,550	1,900
At West South Platte River Drive	7.6	1,650	2,200	2,450	3,000
Weir Gulch					
At Mouth	__[1]	1,850	2,340	2,530	3,190
First Avenue Tributary					
At Mouth	1.5	410	670	740	1,030
Dakota Avenue Tributary					
At Mouth	0.7	200	300	355	465
Sand Creek					
Downstream of Confluence with Westerly Creek	184.0	10,000	22,400	30,000	33,000
Sand Creek Overflow					
1,030 Feet Above Confluence with Sand Creek	__[1]	__[1]	3,948	7,770	9,394
Sand Creek Smith Road Overflow					
At Divergence from Sand Creek	__[1]	__[1]	__[1]	420	726
South Platte River (Main Channel Only)					
At West Dartmouth Avenue	__[1]	6,400	12,700	16,500	31,500
At Alameda Avenue	__[1]	7,550	15,000	19,200	31,500
At 15th Street	__[1]	9,700	17,600	22,300	35,000
South Platte River (Franklin Street Overflow)					
At Divergence From South Platte River	__[1]	__[1]	__[1]	225	3875
Westerly Creek					
At Mouth	__[1]	3,680	5,780	6,790	9,150
At Colfax Avenue	__[1]	570	870	1,000	1,320

[1] Data Not Available

Table 2. Summary of Discharges (Cont'd)

		Peak Discharges (cfs)			
Flooding Source and Location	Drainage Area (Square Miles)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Westerly Creek Overflow					
At Confluence with Westerly Creek	__[1]	__[1]	__[1]	471	__[1]
Westerly Creek Tributary					
1,680 Feet Upstream of Confluence with Westerly Creek	__[1]	__[1]	__[1]	98	__[1]
South Monaco Street Parkway Overflow					
At Intersection of South Monaco Street Parkway and Florida Avenue	__[1]	24	158	262	456

[1] Data Not Available

Due to overbank split flows, a floodway along the South Platte River was not delineated.

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater computer program (Reference 46).

A brief discussion of the hydraulic analysis of each stream studied by detailed methods follows:

Clear Creek

Cross section data, Manning's "n" values, and starting water- surface elevations were obtained from the 1979 UDFCD Flood Hazard Area Delineation report for Clear Creek (Reference 22). Cross section data for the HEC-2 analysis were compiled from topographic mapping (Reference 47). Typical roughness or Manning's "n" values used were 0.025 to 0.045 for the channel and 0.040 to 0.075 for the overbank areas.

Bear Creek

Cross section data, Manning's "n" values, and starting water-surface elevations were developed for use in the 1979 UDFCD Flood Hazard Area Delineation report for Bear Creek (Reference 48). Cross section data were obtained photogrammetrically by digitizing cross sections marked on aerial photographs of the stream channel and floodplain (Reference 49). The digitized cross section data were supplemented with cross sections taken from topographic mapping (Reference 50) developed from the aerial photography. All bridge cross sections were obtained from actual field measurements. Roughness coefficients for the channel and overbank areas were estimated by field inspection of the study area. Manning's "n" values were 0.035 in the channel and from 0.025 to 0.090 in the overbank areas.

Additional cross sections were included from channel improvement plans due to recent grading and channel improvements in the vicinity of Lowell Boulevard.

Cherry Creek

Cross section data, Manning's "n" values, and starting water- surface elevations were obtained from the 1976 UDFCD Flood Hazard Area Delineation report for Cherry Creek (Reference 10).

Revised cross sections reflecting recent channel improvements in the areas of Bannock Street to First Avenue were obtained from the Wastewater Management Division of the Denver Department of Public Works Cherry Creek channel improvements reports (References 51 and 52).

Lakewood Gulch and Lakewood Gulch Overflow

Cross section data, Manning's "n" values, and starting water- surface elevations were obtained from the 1979 UDFCD Flood Hazard Area Delineation report for Lakewood Gulch (Reference 53). The starting water-surface elevations for Lakewood Gulch were established using the elevation of a 10-year flood on the South Platte River at its confluence with Lakewood Gulch. The starting water-surface elevations for Lakewood Gulch Overflow were taken from the Lakewood Gulch profile at the confluence with Lakewood Gulch Overflow. Values of Manning's "n" on Lakewood Gulch were selected in order to model the roughness of the streambed and overbank areas. Each cross section or group of cross sections was evaluated and assigned a Manning's "n" value for the left overbank, the channel, and the right overbank. Selected Manning's "n" values ranged from as low as 0.02 for street crossings and parking lots to as high as 0.08 for overbank areas restricted by buildings or debris. At a typical channel section, consisting of a natural channel with natural overbank areas, the generally selected Manning's "n" values were between 0.030 and 0.035 in the main channel, and between 0.045 and 0.050 in the overbank areas. In overbank areas that were restricted by buildings, Manning's "n" values of 0.08 were used when it was felt that a flow of water could occur through the developed area.

Dry Gulch (Lakewood Gulch Tributary)

Cross section data, Manning's "n" values, and starting water- surface elevations were obtained from the 1977 UDFCD Flood Hazard Area Delineation report for Dry Gulch and its tributaries (Reference 12). Values of Manning's "n" used in that report ranged from as low as 0.017 for streets and parking lots to as high as 0.100 for overbank areas restricted by buildings. In general, areas of natural channel section with natural overbanks were assigned Manning's "n" values of approximately 0.045 and 0.080. Where buildings represented significant obstructions to the channel flow, they were represented in the cross sections as total blockages. Starting water-surface elevations were determined from the Lakewood Gulch flood profiles.

Harvard Gulch, Harvard Gulch Overflow. West Harvard Gulch, and Dry Gulch (Harvard Gulch Tributary)

Cross section data, Manning's "n" values, and starting water- surface elevations were developed for use in the 1979 UDFCD Flood Hazard Area Delineation report for Harvard Gulch, West Harvard Gulch, and Dry Gulch (Harvard Gulch Tributary) (Reference 14). Cross section information was obtained photogrammetrically by digitizing cross sections marked on aerial photographs of the stream channel and floodplain (Reference 54). The digitized cross section information was supplemented with cross sections taken from topographic mapping (Reference 55) developed from the aerial photography. All cross sections at bridges were obtained from field measurement.

Estimates of channel and overbank roughness coefficients were made after field investigation of the study areas. Manning's "n" values ranged from 0.015 to 0.040 in the channel and from 0.035 to 0.120 in the overbank areas.

Starting water-surface elevations for Harvard Gulch and West Harvard Gulch were obtained at control sections. The control on Harvard Gulch was a broadcrested weirflow section over South Logan Street, and on West Harvard Gulch, a broadcrested weir section over West South Platte River Drive. Starting water-surface elevations for Harvard Gulch Overflow were taken from the Harvard Gulch profile. For Dry Gulch (Harvard Gulch Tributary), the starting water-surface elevations were also taken from the Harvard Gulch profile because these streams are likely to peak at close to the same time.

Areas of shallow flooding along West Harvard Gulch and Dry Gulch (Harvard Gulch Tributary) were determined using normal-depth calculations. Shallow flooding along Harvard Gulch was determined using normal-depth calculations and a network analysis of floodflows and depths along roads.

Goldsmith Gulch and Southmoor, Park Tributary

Cross section data, Manning's "n" values, and starting water- surface elevations were developed for use in the 1976 UDFCD Flood Hazard Area Delineation report for Goldsmith Gulch and its tributaries (Reference 15). Cross section information was obtained from topographic maps (Reference 56). Typical Manning's "n" values for Goldsmith Gulch and Southmoor Park Tributary ranged from 0.030 to 0.045 in the channel, and from 0.035 to 0.055 in the overbank areas. Starting water-surface elevations for Southmoor Park Tributary were taken from the Goldsmith Gulch profiles. Starting water-surface elevations for Goldsmith Gulch were determined using a rating curve.

Additional cross sections, added at a berm along Goldsmith Gulch near the confluence with Cherry Creek, were taken from Cherry Creek improvement plans (Reference 51). Additional cross section data from improvement plans were included along Goldsmith Gulch and Southmoor Park Tributary for the more recent construction of Eastman Avenue.

Sanderson Gulch

Cross section data on Sanderson Gulch used in the hydraulic analyses were taken from construction drawings, as-built construction drawings, field surveys, and topographic mapping (Reference 57). The starting water-surface elevations were computed using the West South Platte River Drive crossing as a control. Roughness coefficients were estimated after field investigation and ranged from 0.015 to 0.060 in the channel and from 0.035 to 0.100 in the overbank areas.

At Lipan Street along Sanderson Gulch, flows escape along the left overbank and extend to the South Platte River as shallow flooding. These shallow flooding areas were determined using normal-depth calculations.

A portion of flooding on Sanderson Gulch from South Sheridan Boulevard (State Highway 95) downstream to cross section BQ has been labeled with a Profile Base

Line. Flooding backs up at the culvert under South Sheridan Boulevard and flows over the road at a low spot just-north of the culvert.

Weir Gulch

Cross section data for Weir Gulch were obtained from construction drawings (References 26-30), field surveys, and topographic mapping (Reference 57). The starting water-surface elevations were obtained assuming a simultaneous 10-year runoff event on the South Platte River. Roughness coefficients were determined by field inspection on the channel and overbank areas, and ranged from 0.013 to 0.050 and from 0.013 to 0.055, respectively.

For the channel improvements along Weir Gulch which extend from West Alameda Avenue to Sheridan Boulevard, cross sectional data for the hydraulic analysis were taken from information prepared for the Weir Gulch project (Reference 31). Supplemental field observations and design information were used where needed. The starting water-surface elevations were taken from the Preliminary Flood Insurance Study for the City and County of Denver, dated September 27, 1988.

All of the bridges and box culverts within this reach were modeled using the HEC-2 special bridge routine in order to check for pressure flow at these structures. All of these structures convey the 100-year discharge under pressure flow. Manning's "n" values ranged from 0.014 to 0.035 for this reach (Reference 31).

First Avenue Tributary and Dakota Avenue Tributary

Cross section data, Manning's "n" values, and starting water- surface elevations were obtained from the 1977 UDFCD Flood hazard Area Delineation report for the Weir Gulch tributaries (Reference 20). Cross section data were compiled from topographic maps (Reference 58). Starting water-surface elevations were determined by the Weir Gulch water-surface profiles. The Manning`s "n" values were 0.080 for the channel and overbanks on Dakota Avenue Tributary and ranged from 0.025 to 0.080 For the channel and overbanks on First Avenue Tributary.

For the drainage improvements along the Dakota Avenue Tributary, cross sectional data for the hydraulic analysis were taken from information prepared for the Weir Gulch Dakota Avenue Tributary project. Supplemental field observations and design information were used where needed. Improvements included a concrete culvert system which was designed taking into account manhole, bend, and exit losses. It was determined that the hydraulic grade line remains within the system and that the 100-year flood is conveyed by the system. The Manning's "n" value used was 0.014 for this study reach (Reference 32).

Sand Creek

Cross section data, Manning's "n" values, and starting water- surface elevations were obtained from the 1977 UDFCD Flood Hazard Area Delineation report for Sand Creek (Reference 42). Cross section data were compiled from topographic maps

(Reference 59). Manning's "n" values ranged from 0.036 to 0.044 in the channel and from 0.035 to 0.100 in the overbank areas. Backwater computations for determination of the flood profiles were started at the Burlington Ditch Weir, located within the City of Commerce City, where critical depth was assumed.

Between Quebec Street and Havana Street, shallow flooding extends north from Sand Creek, inundating large areas of the Stapleton International Airport with depths averaging from less than 1 foot to 3 feet. Downstream of Quebec Street, shallow flooding extends west from Sand Creek with depths averaging less than 1 foot. Normal-depth calculations were used to determine depths and extent of shallow flooding areas.

<u>South Platte River</u>

Valley cross sections for the South Platte River were developed using digitized cross sections from aerial photography flown April 16, 1983. Where appropriate, river cross sections were field surveyed and incorporated into the digitized cross sections (References 60, 61, 62, and 63). Manning's "n" values ranged from 0.030 to 0.035 in the main channel and from 0.040 to 0.070 in the overbank and split-flow areas. Starting water-surface elevations and channel stationing were obtained from the September 1977 UDFCD Flood Hazard Area Delineation report for the South Platte River in Adams County (Reference 7). Both normal and special bridge routines were used in the HEC-2 computer program to determine bridge losses.

Special split-flow analyses were made for those floodplain reaches where a significant discharge leaves the main channel and flows parallel to the main channel as overland flow until it is forced back into the main channel by the natural topography or a man-made improvement. Separate split-flow profiles are presented for the left (west) bank from 56th Avenue upstream to 47th Avenue, for the left (west) bank from West Jewell Avenue upstream to West Iliff Avenue, and for the right (east) bank from Lawrence Street upstream to 8th Avenue. A separate Profile Base Line was delineated for each split-flow area and is shown on the Flood Insurance Rate Map.

<u>Westerly Creek</u>

The approximate 100-year elevations along Westerly Creek were computed using the COE HEC-2 computer program (Reference 44). Manning's "n" values and cross section data in some portions of Westerly Creek were obtained from the 1977 UDFCD Flood Hazard Area Delineation report for Westerly Creek (Reference 64). Additional cross section data were obtained from construction drawings for recent channel improvements (Reference 65). Starting water-surface elevations were determined in the 1977 Major Drainageway Planning report for Westerly Creek (Reference 11).

Coon Creek and Other Tributaries

Elevations for Coon Creek, First Creek, First Creek Tributary T, Sloans Lake Basin, and Marston Lake North Drainage Basin, which are presented in this Flood Insurance Study as approximate study areas, were determined previously as part of the following UDFCD reports: the Flood Hazard Area Delineation report for Dutch Creek, Lilley Gulch, Coon Creek, and Three Lakes Tributary (Reference 66); the Major Drainageway Planning report for First Creek (Reference 67); the Flood Hazard Area Delineation report for Sloans Lake Basin (Reference 68); and the Flood Hazard Area Delineation report for Marston Lake North Drainage Basin (Reference 69).

Due to the channel improvements along a reach of Coon Creek from State Highway 121 to a point approximately 1,850 feet upstream at Southwest Commons, the 100-year recurrence interval flood is contained in the channel. The hydraulic analyses for this study were based on unobstructed flow (Reference 25).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the flood profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Generally, the distances on the flood profiles correspond to distances measured along the centerline of the designated watercourses. In several areas, however, the meandering nature of the low-flow streambeds necessitated use of distances measured along the centerline of the 100-year flow paths. On the maps, these flow lines, used to establish the respective profile distances, are delineated and labeled as Profile Base Lines.

Excepting some overland flow across South Wadsworth Boulevard, the 100-year recurrence interval flood is contained in the channel. This is due to channel improvements and the addition of culverts and a sedimentation control basin along a reach of Marston Lake North, from Vaile Lake to a point approximately 3,600 feet upstream of Highway 121. The hydraulic analyses for this study were based on unobstructed flow. Manning's "n" values ranged from 0.013 to 0.035.

All elevations are referenced to the National Geodetic Vertical Datum (NGVD) of 1929. Elevation reference marks used in this study are shown on the maps.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at scales of 1:20, 1:1,200 and 1:24,000, with contour intervals of 1, 2 and 10 feet (References 47, 50, 55-59, 61, 63, 70, 71, 72, and 73).

Boundaries for the shallow flooding areas were delineated using topographic maps at scales of 1:1,200 and 1:24,000, with contour intervals of 2 and 10 feet (References 55, 57, 58, 59, 61, and 63) in conjunction with the previously determined elevations.

For the streams studied by approximate methods, the boundaries of the 100-year flood were delineated an topographic maps at scales of 1:600 and 1:1,200, with contour intervals of 1 and 2 feet (References 61, 62, and 74-80).

Approximate floodplain boundaries in some portions of the study area were taken from the Flood Hazard Boundary Map (Reference 81). The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to imitations of the map scale and/or lack of detailed topographic data. For the streams studied by approximate methods, only the 100-year floodplain boundary is shown.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

A floodway was not computed for Cherry Creek because the determination of a floodway was not within the scope of this study.

Harvard Gulch, downstream of South Logan Street, and Dakota Avenue Tributary are shallow flooding areas for which the floodway concept is not applicable.

No floodway has been presented for Harvard Gulch between South Ogden and South Logan Streets and for Harvard Gulch Overflow due to the fully developed nature of this area.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the floodplain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 3).

As shown on the Flood Insurance Rate Map, the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.

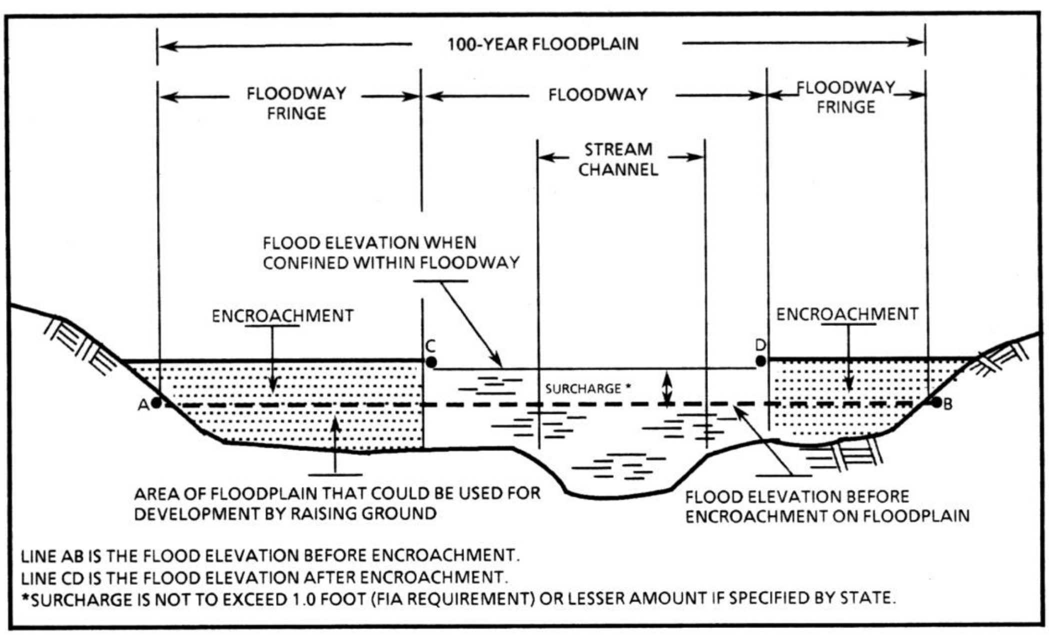


Figure 2. Floodway Schematic

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/ SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Coon Creek								
A	14,444	167	1,055	2.0	5,550.4	5,550.4	5,550.5	0.1
B	14,796	235	1,373	1.6	5,550.5	5,550.5	5,550.6	0.1
C	15,462	94	503	4.2	5,562.5	5,562.5	5,562.5	0.0
D	15,796	89	296	6.8	5,565.8	5,565.8	5,565.8	0.0
E	16,166	107	516	3.9	5,570.1	5,570.1	5,570.1	0.0
F	16,795	81	307	6.6	5,572.1	5,572.1	5,572.1	0.0

[1]Feet above confluence with Dutch Creek

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF DENVER, CO

FLOODWAY DATA

COON CREEK

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains determined in the Flood Insurance Study by detailed methods. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheetflow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year floodplains, the floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE(S)	FLOOD INSURANCE RATE MAP EFFECTIVE DATE	FLOOD INSURANCE RATE MAP REVISION DATE(S)
City and County of Denver	12/28/1975	4/15/1977	4/15/1986	9/28/1990 8/3/1992 4/16/1993 3/4/1996 9/7/1998 11/17/2005 11/20/2013

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY AND COUNTY OF DENVER, CO

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

Several floodplain studies have been conducted for streams throughout the Denver area. The results of these studies were reviewed and were incorporated where appropriate in this Flood Insurance Study.

The COE, Omaha District, prepared a Preliminary Flood Plain Information report for the South Platte River in 1980 (Reference 60). Hydraulic and hydrologic data from that report were used in this study.

The UDFCD published a report on the South Platte River in September 1985 covering the Denver Metropolitan Area from Sand Creek upstream to Oxford Avenue. Discharges and flood elevations from this report were used in this revised study (Reference 44).

A Flood Hazard Area Delineation report for Clear Creek was published in 1979 (Reference 22). That report contained hydrologic and hydraulic data for fully developed basin conditions; those data are in agreement with the analyses used in this study.

A Special Flood Hazard Information report for Bear Creek was published in 1972 (Reference 82). That report included a hydrologic analysis of Bear Creek using 1970 channel conditions and development. The report was completed before the construction of the Bear Creek Dam; therefore, discharges and flood elevations determined in the report do not reflect present-day flooding conditions.

The COE prepared a hydrologic analysis for Bear Creek downstream of Bear Creek Dam (Reference 24). Peak discharges were developed for different basin conditions. The discharge values developed using full basin development conditions are in agreement with the discharges used in this study.

A Flood Hazard Area Delineation report for Bear Creek was published in 1979 (Reference 48). Hydrologic and hydraulic data for fully developed basin conditions, which were presented in that report, were utilized in this study.

A Flood Hazard Area Delineation report for Cherry Creek was published in 1976 (Reference 10). Data from that report were utilized wherever possible in this study; however, channel improvements completed in 1980 and 1981 necessitated recomputing the water-surface profiles in some areas.

The UDFCD published several reports on Westerly Creek. The earliest report, published in 1976 (Reference 83), was superseded the next year by a Flood Hazard Area Delineation report (Reference 64) and a Major Drainageway Planning report (Reference 1-1). The 100-year floodplain boundaries shown in this study reflect some recent channel improvement and will therefore not agree with the previously published reports.

The UDFCD published a 1978 Flood Hazard Area Delineation report which covered Coon Creek (Reference 66). The 100-year floodplain boundaries for Coon Creek presented in that report were used in this study.

The UDFCD published two reports on Lakewood Gulch. The hydrologic analysis presented in the 1976 Major Drainageway Planning preliminary report (Reference 39) was used in the 1979 Flood Hazard Area Delineation report (Reference 53). The hydrologic and hydraulic data presented in those reports were utilized in this study.

The UDFCD published Flood Hazard Area Delineation reports for Dry Gulch (Reference 12) and for Harvard Gulch, West Harvard Gulch, and Dry Gulch (Reference 14). The hydrologic and hydraulic data presented in those reports were utilized in this study.

The UDFCD published a Flood Hazard Area Delineation report for Goldsmith Gulch and its tributaries in 1976 (Reference 15). Hydrologic and hydraulic data in that report for Goldsmith Gulch and Southmoor Park Tributary were used in this study. However, 100- and 500-year boundaries in some portions of Goldsmith Gulch and Southmoor Park Tributary have been revised in this study to reflect recent channel improvements.

The UDFCD published a 1979 Flood Hazard Area Delineation report for Sanderson Gulch (Reference 17). Hydrologic and hydraulic data from that report were utilized in this study.

The UDFCD published a 1972 Major Drainageway Planning report for Sanderson and Weir Gulches (Reference 41). Hydrologic data from that report were used in this study for Sanderson Gulch and Weir Gulch. Flood boundaries and water-supply profiles presented in this study reflect recent channel improvements and, therefore, will not agree with the previously published report. Peak discharge data for Weir Gulch downstream of Barnum Lake were revised in this study due to channel improvements and the construction of an additional culvert under West 6th Avenue (U.S. Highway 6).

The UDFCD published a Flood Hazard Area Delineation report for the Weir Gulch tributaries in 1977 (Reference 20). Hydrologic and hydraulic information for First Avenue Tributary and Dakota Avenue Tributary was included for use in this study. Due to a review of the hydraulic data and normal-depth calculations, flooding along Dakota Avenue Tributary has been identified as shallow flooding with average depths of 1.0 foot in this study.

The UDFCD published a Flood Hazard Area Delineation report for Sand Creek (Reference 42). Hydrologic and hydraulic data from that report were used in the analysis of Sand Creek for this study.

In 1977, the UDFCD published a Major Drainageway Planning report for First Creek and First Creek Tributary T (Reference 67). The hydrologic and hydraulic analyses in that report were based on fully developed basin conditions. The 100-year floodplain boundaries presented in the report were used in the previous study. An update to the planning report, entitled “First Creek (upstream of Buckley Road) Major Drainageway Plan”, was completed by UDFCD in August 2010. The updated floodplain boundaries were incorporated into the DFIRM as a full detailed study.

The UDFCD published Flood Hazard Delineation reports for Sloans Lake Basin (Reference 68) and Marston Lake North Drainage Basin (Reference 69). The 100-year drainage basin boundaries presented in these reports were used in this study as approximate studies for Sloans Lake Basin and Marston Lake North Drainage Basin.

A Flood Hazard Boundary Map has been published for the City and County of Denver (Reference 81). Floodplain boundaries determined for this study supersede the Flood Hazard Boundary Map.

A revised Flood Insurance Rate Map has been prepared for the City of Aurora (Reference 84). Flooding on Westerly Creek was studied by detailed methods in Aurora, whereas the Denver study presents it as an approximate analysis. In all other areas, the two studies are in agreement.

A Flood Insurance Study has been prepared for the City of Commerce City, in Adams County (Reference 85). The 100-year floodplain boundaries along the South Platte River agree at the Denver/Commerce City corporate limits at the Franklin Street Bridge. Zone X shallow flooding originating from the right bank of Sand Creek upstream of Commerce City was determined in the Denver Flood Insurance Study to flow north and northwest along the overbanks. The flows were only analyzed in the Denver study as far as Quebec Street which forms the eastern corporate limits between Denver and Commerce City. This shallow flooding was not analyzed as part of the Commerce City Flood Insurance Study. In all other areas, the two studies are in agreement.

A Flood Insurance Rate Map has been prepared for the City of Wheat Ridge (Reference 86). There is a discrepancy between the 100-year zone designation determined for Clear Creek for this study and the zone designation shown on the Wheat Ridge FIRM. This difference is due to the different reach length used to determine the zone designation in each study. In all other areas, the two studies are in agreement.

A Flood Insurance Study has been published for Adams County (Reference 87). That study is in agreement with this study, with the exception of flooding along First Creek and First Creek Tributary T. The 100-year floodplain boundaries along First Creek disagree between the two studies; it has been determined that the Denver study more accurately presents the flooding and that the Adams County study will be revised at some future time to match it. Flooding on First Creek Tributary T was analyzed by approximate methods in the Denver study, but was not analyzed in the Adams County study. A revised, detailed analysis of flooding along the reach of the South Platte River upstream of Interstate Highway 270 is being completed for Adams County. Thus the 100-year floodplain boundaries and the base flood elevations agree with those for this Denver study at the Adams County line (Franklin Street Bridge).

A Flood Insurance Study has been prepared for the City of Cherry Hills Village (Reference 88). Blackmer Gulch was studied by detailed methods within Cherry Hills Village upstream to Whitehall Drive, which forms the corporate limits between Cherry Hills Village and Denver. Blackmer Gulch was not studied as part of the Denver Flood Insurance Study. In all other areas, the two studies are in agreement.

A Flood Insurance Rate Map has been prepared for the City of Englewood (Reference 89). West Harvard Gulch, studied by detailed methods in the Denver Flood Insurance Study, was not studied as part of the Englewood study. In all other areas, the two studies are in agreement.

A Flood Insurance Study has been prepared for the City of Sheridan (Reference 90). The Sheridan study was completed before the construction of the Bear Creek Dam located just downstream of the Town of Morrison in Jefferson County. Hydrologic and hydraulic analyses of Bear Creek for the Denver Flood Insurance Study consider the construction of the dam and are more representative of present-day flooding conditions.

A revised Flood Insurance Rate Map has been published for the City of Lakewood (Reference 91). That Flood Insurance Rate Map is in agreement with this study with the following exceptions:

(1) Flooding from Lakewood Gulch in Lakewood does not agree with the detailed analyses of Lakewood Gulch within Denver. Lakewood Gulch flooding determined for this study is a more recent analysis and, therefore, supersedes the Lakewood Flood Insurance Rate Map.

(2) Floodplain boundaries for 500-year flooding were not determined for Weir Gulch, Dakota Avenue Tributary, First Avenue Tributary, Dry Gulch (Lakewood Gulch Tributary), and Sanderson Gulch within Lakewood due to the limited scope of study.

(3) Dakota Avenue Tributary flooding has been identified as shallow flooding downstream of Sheridan Boulevard (State Highway 95) in this study.

(4) On Weir Gulch and First Avenue Tributary, 100-year elevations and floodplain boundaries are in disagreement with those determined for this study. This study is a more recent analysis and, therefore, supersedes the Lakewood Flood Insurance Rate Map.

(5) Bear Creek is presented as an approximate study within Lakewood and as a detailed study within Denver.

A Flood Insurance Study and Flood Insurance Rate Map have been published for the City of Littleton (Reference 92). Flood Insurance Rate Maps have been published for the City of Greenwood Village and for Arapahoe County (References 93, 94, and 97). A Flood Hazard Boundary Map has been prepared for the City of Edgewater (Reference 95). These adjacent studies are in general agreement with this study.

A Flood Hazard Boundary Map has been published for the unincorporated areas of Jefferson County (Reference 96). Flooding determined for this study represents more recent analysis and, therefore supersedes the Jefferson County Flood Hazard Boundary Map.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Mitigation Division, Denver Federal Center, Building 710, Box 25267, Denver, Colorado 80225-0267.

9.0 BIBLIOGRAPHY AND REFERENCES

1. Colorado State University, County Information Service, Denver County Data Book, 1979.

2. U.S. Department of Agriculture, Soil Conservation Service, General Soil Map of Colorado, Prepared by the Colorado State University Experiment Station, April 1976.

3. U.S. Department of the Army, Corps of Engineers, Omaha District, Flood Plain Information Study, South Platte River, August 1968.

4. U.S. Department of the Army, Corps of Engineers, Omaha District, Post Flood Report, Platte River and Tributaries, Nebraska. Wyoming, and Colorado. Floods of May and June 1973, Volume II, July 1974.

5. U.S. Department of the Army, Corps of Engineers, Omaha District, Report on the Floods of June 1965, South Platte River Basin, Colorado and Nebraska, January 1967.

6. U.S. Department of the Interior, Geological Survey, Water-Supply Paper No. 997, Floods in Colorado, 1948.

7. Urban Drainage and Flood Control District and Colorado Water Conservation Board, Flood Hazard Area Delineation - South Platte River. Adams County, Colorado, Prepared by Gingery Associates, Inc., Englewood, Colorado, September 1977.

8. U.S. Department of the Army, Corps of Engineers, Omaha District, Floodplain Information. Metropolitan Region, Denver, Colorado, Volume III, Clear Creek, January 1966.

9. Colorado Water Conservation Board, Special Flood Hazard Information Report for Bear Creek, Prepared by U.S. Department of the Army, Corps of Engineers, Omaha District, December 1972.

10. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Cherry Creek, Prepared by Merrick and Company, Denver, Colorado, July 1976.

11. Urban Drainage and Flood Control District, Major Drainageway Planning - Westerly Creek, Volumes I & II, Prepared by Camp Dresser & McKee, Inc., Denver, Colorado, February 1977.

12. Urban Drainage and Flood Control District Flood Hazard Area Delineation - Dry Gulch and Tributaries, Prepared by Sellards & Grigg, Inc., Lakewood, Colorado, November 1977.

13. Kenneth R. Wright, "Harvard Gulch Flood Control Project," Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, March 1967.

14. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Harvard Gulch, West Harvard Gulch, and Dry Gulch, Prepared by Gingery Associates, Inc., Englewood, Colorado, December 1979.

15. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Goldsmith Gulch and Tributaries, Prepared by Gingery Associates, Inc., Englewood, Colorado, June 1976.

16. U.S. Geological Survey and Urban Drainage and Flood Control District, Storm of May 5-6, 1973, in the Denver Metro Area: Frequency and Effect, Prepared by Ducret and Hansen, 1973.

17. Urban Drainage and Flood Control District, Flood Hazard Delineation - Sanderson Gulch and North Sanderson Gulch, Prepared by Gingery Associates, Inc., August 1979.

18. U.S. Department of the Army, Corps of Engineers, Flood Plain Information, Volume V, Denver Metropolitan Region. Colorado, November 1970.

19. U.S. Department of the Army, Corps of Engineers, Flood Plain Information. Volume IV, Denver Metro Region, Colorado, October 1968.

20. Urban Drainage and Flood Control District, Flood Hazard Area Delineation-Weir Gulch Tributaries, Prepared by Centennial Engineering, Inc., July 1977.

21. U.S. Department of the Army, Corps of Engineers, Omaha District, Interim Report on Sand and Toll Gate Creeks, Colorado, Volumes I and II, August 1969 (revised January 1972).

22. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Clear Creek, Prepared by Gingery Associates, Inc., Englewood, Colorado, November 1979.

23. U.S. Department of the Army, Corps of Engineers, Omaha District, Hydrology for Clear Creek, Jefferson and Adams Counties Colorado, January 1978.

24. U.S. Department of the Army, Corps of Engineers, Omaha District, Hydrology Review for Lower Bear Creek, August 1978.

25. Correspondence from Roger L. Meiden dated November 23, 1988, Drexel Barrell Engineers/Surveyors Incorporated.

26. City and County of Denver, Department of Public Works, Wastewater Management Division, Weir Gulch Drainage Improvements, Schedule VI (South Platte River to Bryant Street), 1980, as constructed.

27. City and County of Denver, Department of Public Works, Wastewater Management Division, Weir Gulch Drainage Improvements. Schedule V (W. 8th Avenue to Bryant Street), June 1980.

28. City and County of Denver, Department of Public Works, Wastewater Management Division, Weir Gulch Drainage Improvements, Schedule IV (Federal Street to Hooker Street).

29. City and County of Denver, Department of Public Works, Wastewater Management Division, Weir Gulch Drainage Improvements, Schedule III (Perry Street to Hooker Street), 1981, as constructed.

30. City and County of Denver, Department of Public Works, Wastewater Management Division, Weir Gulch Drainage Improvements, Schedule II (Alameda Avenue to Perry Street).

31. Weir Gulch - Request for Letter of Map Revision, Prepared by Love and Associates, Inc., Boulder, Colorado, June 1989.

32. Weir Gulch Dakota Avenue Tributary - Request for Letter of Map Revision, Prepared by Love and Associates, Inc., Boulder, Colorado, June 1989.

33. HEC-2 Flood Profile Analysis for Marston Lake North Drainageway, Prepared by RMC, Inc., October 1989.

34. Hydraulic Analysis and Floodplain Revision for Marston Lake North Drainageway Improvements, Prepared by WRC, Inc., August 1989.

35. U.S. Water Resources Council, Hydrology Committee, "Guidelines for Determining Flood Flow Frequency," Bulletin No. 17, March 1976.

36. U.S. Office of Water Resource Research, Massachusetts Institute of Technology Catchment Model (MITCAT), Prepared by Massachusetts Institute of Technology.

37. U.S. Environmental Protection Agency, Storm Water Management Model, Version II, Environmental Research Center, Cincinnati, Ohio.

38. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Precipitation-Frequency Atlas of the Western United States, Volume II, Colorado, 1973.

39. Urban Drainage and Flood Control District, Preliminary Report on Major Drainageway Planning on Lakewood and McIntyre Gulches, Volume I, Phase A, Prepared by McCall-Ellingson & Morrill, December 1975, Revised January 1976.

40. Urban Drainage and Flood Control District, Urban Storm Drainage Criteria Manual, Volumes I & II, Wright-McLaughlin Engineers, Denver, Colorado, March 1969.

41. Urban Drainage and Flood Control District, Major Drainageway Planning, Sanderson Gulch and Weir Gulch, Volumes I & II, Prepared by Frasier & Ginger, Inc., August 1972.

42. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Sand Creek, March 1977.

43. U.S. National Weather Administration, Environmental Science Services, Office of Hydrology, Special Studies Branch, Precipitation-Frequency Values, October 1967.

44. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - South Platte River, Denver Metropolitan Area, Sand Creek to Oxford Avenue, Prepared by Wright Water Engineers, Inc., Denver, Colorado, September 1985.

45. Urban Drainage and Flood Control District, South Platte River Hydrologic Study, Chatfield Dam to Sand Creek, Prepared by Merrick and Company, Denver, Colorado, May 1983.

46. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2, Water-Surface Profiles, Generalized Computer Program, Davis, California, April 1980, Revised September 1990.

47. Bell Mapping Company, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Clear Creek, November 1976.

48. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Bear Creek, Prepared by Gingery Associates, Inc., December 1979.

49. Scharf and Associates, Inc., Aerial Photography, Scale 1:1,200, Bear Creek, January 1979.

50. Scharf and Associates, Inc., Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Bear Creek, January 1979.

51. Department of Public Works, Wastewater Management Division, Cherry Creek Channel Improvements, Project Number W76-116, Prepared by Merrick and Company, Denver, Colorado, 1977.

52. Department of Public Works, Wastewater Management Division, Cherry Creek Channel Improvements, Project Number W76-116A, Phase IA, Prepared by Merrick and Company, Denver, Colorado, 1981.

53. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Lakewood Gulch, Prepared by Sellards and Grigg, Inc., Lakewood, Colorado, February 1979.

54. Delta Aerial Surveys, Inc., Aerial Photography, Scale 1:1,200, Harvard Gulch, Harvard Gulch Overflow, West Harvard Gulch and Dry Gulch (Harvard Gulch Tributary), May 1979.

55. Delta Aerial Surveys, Inc., Topographic Mapping, Scale 1:1,200, Contour Interval 2 feet: Harvard Gulch, Harvard Gulch Overflow West Harvard Gulch, and Dry Gulch (Harvard Gulch Tributary), May 1979.

56. Kucera and Associates, Inc., Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Goldsmith Gulch and Southmoor Park -Tributary, February 1973.

57. Falcon Air Maps, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Sanderson Gulch and Weir Gulch, July 1969.

58. Delta Aerial Surveys, Inc., Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: First Avenue Tributary and Dakota Avenue Tributary, November 1976.

59. Bell Mapping Company, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Sand Creek, July 1974.

60. U.S. Department of the Army, Corps of Engineers, Omaha District, South Platte River Floodplain Information, Preliminary Technical Write-up, South Platte River through Denver. Colorado, October 1980.

61. Delta Aerial Surveys, Inc., Denver, Colorado, Topographic Maps, Scale 1:2,400, Contour Interval 2 feet: South Platte River, April 1983.

62. Bell Mapping Company, Denver, -Colorado, Topographic Maps, Scale 1:600, Contour Interval 1 foot: South Platte River, July 1974.

63. U.S. Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 10 feet: Arvada, 1965 (Photorevised 1971); Commerce City, 1965 (Photorevised 1971); Fort Logan, 1965 (Photorevised 1971); Englewood, 1965 (Photorevised 1971); Sable, 1965 (Photorevised 1979).

64. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Westerly Creek, Prepared by Camp, Dresser and McKee, Inc., January 1977.

65. Urban Drainage and Flood Control District, City of Aurora, City and County of Denver, Westerly Creek Drainageway Improvements, Schedules I & II, Prepared by Merrick & Company, Denver, Colorado, August 1978 and July 1979.

66. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Dutch Creek. Lilley Gulch, Coon Creek, and Three Lakes Tributary, Prepared by URS Company, Denver, Colorado, May 1978.

67. Urban Drainage and Flood Control District, Major Drainageway Planning, First Creek, Phase B, Volumes I & II, Prepared by Engineering Consultants, Inc., Denver, Colorado, March 1977.

68. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Sloans Lake Basin, Prepared by URS Company, Denver, Colorado, October 1977.

69. Urban Drainage and Flood Control District, Flood Hazard Area Delineation - Marston Lake North Drainage Basin, Prepared by Camp, Dresser and McKee, Inc., 1979.

70. Merrick and Company, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Cherry Creek, April 1974.

71. Bell Mapping Company, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2, feet: Lakewood Gulch and Lakewood Gulch Overflow, April 1978.

72. Bell Mapping Company, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Dry Gulch (Lakewood Gulch Tributary) and Tributaries, December 1976.

73. Love and Associates, Inc., Boulder, Colorado, Topographic Maps, Scale 1:20, Contour Interval 1 foot: Weir Gulch Drainage Improvement Project, June.1989.

74. Bell Mapping Company, Denver, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Westerly Creek, June 1974.

75. Delta Aerial Surveys, Inc., Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Coon Creek, April 1977.

76. Merrick and Company, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: First Creek and First Creek Tributary, December 1973.

77. M&I Consulting Engineers, Fort Collins, Colorado, Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Sloans Lake Basins, December 1975.

78. Delta Aerial Surveys, Inc., Topographic Maps, Scale 1:1,200, Contour Interval 2 feet: Marston Lake North, March 1978.

79. Marston Lake North HEC-2 Flood Profile Analysis, Scale 1" = 50', Contour Interval of 2 Feet, Prepared by RMC, Inc., August 1988.

80. Drainage Improvements Marston Lake North Scale 1" = 50', Contour Interval of 1 Foot, Prepared by WRC, Inc., January 1988.

81. U.S. Department of Housing and Urban Development, Flood Hazard Boundary Map, City and County of Denver, Colorado, Scale 1:12,000, April 15, 1977.

82. U.S. Department of the Army, Corps of Engineers, Omaha District, Special Flood Hazard Information Report for Bear Creek, Prepared for the Colorado Water Conservation Board, December 1972.

83. Urban Drainage and Flood Control District, Report on Drainage. Master Plan For Westerly Creek, Denver-Aurora, Phase A, Prepared by Camp, Dresser & McKee, Inc., January 1976.

84. Federal Emergency Management Agency, Flood Insurance Rate Map, City of Aurora, Adams and Arapahoe Counties, Colorado, unpublished.

85. Federal Emergency Management Agency, Flood Insurance Study, City of Commerce City, Adams County, Colorado, April 1977, Revised January 19, 1982, and December 5, 1989.

86. Federal Emergency Management Agency, Flood Insurance Rate Map, City of Wheat Ridge, Jefferson County, Colorado, Scale 1:12,000, May 26, 1972, Revised January 3, 1983.

87. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study. Adams County, (Unincorporated Areas), Colorado August 1978.

88. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study. City of Cherry Hills Village, Arapahoe County, Colorado, August 1, 1978.

89. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Rate Map. City of Englewood, Arapahoe County, Colorado, Scale 1:12,000, December 5, 1979.

90. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Sheridan, Arapahoe County, Colorado, January 1976, Revised July 13, 1976.

91. Federal Emergency Management Agency, Flood Insurance Rate Map, City of Lakewood, Jefferson County, Colorado, Scale 1:12,000, Revised January 3, 1983.

92. Federal Emergency Management Agency, Flood Insurance Study, City of Littleton, Arapahoe and Douglas Counties, Colorado, September 29, 1989.

93. Federal Emergency Management Agency, Flood Insurance Rate Map, City of Greenwood Village, Arapahoe County. Colorado, December 1980.

94. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Rate Map, Arapahoe County, Unincorporated Areas. Colorado, Scale 1:24,000, August 15, 1977.

95. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map. City of Edgewater, Jefferson County, Colorado, Scale 1:7,200, November 14, 1978.

96. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, Jefferson County, Unincorporated Areas, Colorado, Scale 1:24,000, July 5, 1977.

97. Federal Emergency Management Agency, Effective Countywide Flood Insurance Study, Arapahoe County, Colorado, October 1989.

98. Hydrosystems Engineering Consulting Services, Hydrology Study for the Goldsmith Gulch Drainage Basin, March 22, 1990.

99. Sellards & Grigg,. Inc., Goldsmith Gulch LOMR Technical Report, March 1990.

100. Sellards & Grigg, Inc., Goldsmith Gulch LOMR Technical Report HEC-2 Input and Output, Volume 1, March 1990.

101. Sellards & Grigg, Inc., Goldsmith Gulch LOMR Technical Report HEC-2 Input and Output, Volume 2, March 1990.

102. Sellards & Grigg, Inc., Goldsmith Gulch LOMR Technical Report HEC-2 Input and Output, Volume 3, June 1990.

103. U.S. Department of the Army, Corps of Engineers, Omaha District, Kelly Road Dam Revised Discharges Memo, Westerly Creek, Prepared for the Urban Drainage and Flood Control District, July 5, 1979.

104. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Technical Memorandum NWS Hydro-35, Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States, June 1977.

105. Love & Associates, Inc., Request for Letter of Map Revision (LOMR), Westerly Creek, Montview Boulevard to Kelly Road Dam, City of Aurora, Adams County, Colorado and City and County of Denver, Colorado, April 25, 1991.

106. Love & Associates, Inc., Denver, Colorado, Topographic Maps, Scale 1"=100'; Contour Interval 2 feet, Westerly Creek, January 1991.

107. Merrick & Company, Denver, Colorado, LOMR for Westerly Creek Through Lowry Air Force Base, February 1996.

108. Urban Drainage and Flood Control District, Colorado Urban Hydrograph Procedure Computer Program (CUHPF/PC), Denver, Colorado, May 1996.

109. Urban Drainage and Flood Control District, Urban Drainage Storm Water Management Computer Model (UDSWMM), January 1995.

110. Sellards & Grigg, Inc., Goldsmith Gulch Conditional Letter of Map Revision and As-Built Plans - Phase III, Goldsmith Gulch Flood Control Project, December 1994 and September 1996, respectively.

111. Michael Baker Jr., Inc., Review Notes for Technical Review of LOMR, December 1996.

112. Streamline Technologies, Inc., Inter-Connected Pond Routing (ICPR) Computer Program, Version 2.0, December 1994.

113. Moser & Associates, First Creek (Upstream of Buckley Road) Major Drainageway Plan Conceptual Design Report, August 2010.

114. Urban Drainage and Flood Control District, Flood Hazard Area Delineation, Dutch Creek, Coon Creek, Lilley Gulch and Three Lakes Tributary, prepared by PBS&J, March 2008.

10.0 REVISION DESCRIPTIONS

This section has been added to provide information regarding significant revisions made since the original Flood Insurance Study was printed. Future revisions may be made that do not result in the republishing of the Flood Insurance Study report. All users are advised to contact the community repositories of flood hazard data to obtain the most up-to-date flood hazard information.

10.1 First Revision

This study was revised on August 3, 1992, to revise flooding along Goldsmith Gulch in the City and County of Denver, Colorado. Detailed study information is included for Goldsmith Gulch from its confluence with Cherry Creek to Belleview Avenue. This study was performed by Sellards & Grigg, Inc.

Hydrologic analyses were carried out using the Colorado Urban Hydrograph Procedure and the predicted hydrographs were used in the EPA's Storm Water Management Model for hydrograph routing through the drainage network. The 100-year peak discharge for Goldsmith Gulch, at the mouth, is 4,064 cfs (Reference 98).

Selected cross sections were field surveyed to provide channel definition along Goldsmith Gulch (Reference 99). Sellards & Grigg, Inc. was responsible for the hydraulic analyses to determine water-surface profiles and floodway analysis. Several detention ponds were constructed for the purpose of storing floodwaters and reducing peak flows (Reference 99).

Calculated water-surface profiles were developed using the COE Computer Program HEC-2 (References 99-102). Table 3, "Floodway Data," and the Profile Panels (Exhibit 1) for Goldsmith Gulch were revised as a result of this revision.

10.2 Second Revision

This study was revised on April 16, 1993, to revise flooding along Westerly Creek in the City and County of Denver, Colorado. The basis for this revision is revised hydrologic and hydraulic analyses along Westerly Creek from 11th Avenue (within the City and County of Denver) to approximately 1,500 feet downstream of East Avenue (located within the City of Aurora), due to the construction of the Westerly Creek Dam by the COE. Detailed study information is included for Westerly Creek from 11th Avenue to approximately 1,500 feet downstream of East Avenue. This study was performed by Love & Associates, Inc.

Hydrologic analyses were carried out using the EPA's Storm Water Management Model for hydrograph routing through the drainage network. The 100-year peak discharge for Westerly Creek is 6,790 cfs at the mouth and 100 cfs at Kelly Road (Reference 105).

Cross-section data for the HEC-2 backwater analysis were developed by Merrick and Company to reflect constructed channel improvements in the study reach (Reference 106). Calculated water-surface profiles were developed using the COE HEC-2 hydraulic computer model. Floodway Data Tables and Profile Panels for Westerly Creek were added as a result of this revision. The Summary of Discharges Table was also revised to reflect this revision.

10.3 Third Revision

This study was revised on March 4, 1996, to modify the flooding along Sand Creek in the City and County of Denver, Colorado. The basis for this revision was to incorporate updated topographic information and the effects of the construction of bridges and channel improvements along Sand Creek through the Stapleton International Airport. The analysis for this revision was performed by Kiowa Engineering Corporation, Denver, Colorado, for the UDFCD.

Approximately three miles of the Sand Creek floodplain was revised, beginning at the eastern corporate limits for the City and County of Denver and extending downstream of the airport boundary to Interstate 70 (1-70).

Meetings were held during the course of the study with the UDFCD and local representatives to review the as-built drawings of the bridges, the revised floodplain and floodway delineations, and mapping provided by the City of Denver.

The original Flood Insurance Study was prepared using the 100-year floodplain delineation and profile information from the Sand Creek Flood Hazard Area Delineation Map, prepared for the UDFCD by the COE in 1977. However, this report was not the source of the 100-year floodway. As part of this revision, the 100-year floodplain and floodway models were duplicated using the COE HEC-2 Water-Surface Profile Program (Reference 46). The hydraulic analyses for the revised conditions were also developed from the HEC-2 model.

The effective discharges were used for this revision. The 100-year starting water-surface elevation for the revised reach of Sand Creek was the computed 100-year water-surface elevation at the downstream tie-in section as shown in the Floodway Data Table for Sand Creek.

Cross-section data were obtained from the topographic mapping. Roughness values were estimated using the existing Flood Insurance Study HEC-2 models, the Urban Storm Drainage Criteria Manual, and field observations. Channel roughness values for the channel ranged from .016 to .043. Overbank roughness values ranged from .016 to .050. The bridge opening at the three new bridges were field measured. Bridge routines modeled were checked against current field conditions.

Floodway encroachments were set to define the effective flow areas.

In response to an appeal from the UDFCD of the flood hazard information presented in the preliminary revised Flood Insurance Study report and on the Flood Insurance Rate Map for the City and County of Denver, Colorado, dated November 30, 1994, FEMA reevaluated the source of flooding in the low area located north of Sand Creek and east of the Stapleton International Airport runways. As a result of this reevaluation, FEMA determined that flooding in this low area is due to overflow from Sand Creek along the north overbank area in the vicinity of Cargo Bridge Road, hereafter referred to as the Sand Creek Overflow. A total of 640 cfs is lost from Sand Creek at this location. A portion of this overflow, 39 cfs, is lost through the Union Pacific Railroad (UPRR) culvert beneath the runway, and returns to Sand Creek just downstream of the UPRR bridge, while the remaining 601 cfs flows into the Sand Creek Overflow and returns to Sand Creek just upstream of the 1-70 bridges. The Sand Creek Overflow follows a flowpath that can be defined as, and is in the form of, concentrated riverine flow with average depths in excess of 2 feet. Based on FEMA's reevaluation, the Special Flood Hazard Area (SFHA) for this area was redelineated and designated Zone AE with base (100-year) flood elevations (BFEs) shown.

The hydraulics along Sand Creek between the 1-70 and UPRR bridges were also reevaluated. A split-flow condition exists along the northern bank of Sand Creek from approximately 200 feet downstream of Cross Section N to the UPRR bridge. Using the HEC-2 split-flow option, it was determined that a total of 12,239 cfs is lost from the Sand Creek base flood flow through this reach. Flow between the ridge along the north bank of Sand Creek and the south bank of the low-lying area adjacent to 1-70 is shallow overland flow with average depths of 1 foot. The SFHA delineations along Sand Creek and the low-lying area adjacent to 1-70 were revised slightly. The BFEs along Sand Creek have been lowered as a result of this overflow condition. The floodway designation through this reach of Sand Creek has been removed because this overflow cannot be fully confined to Sand Creek without exceeding the 1-foot surcharge limit for floodways.

The 100-year water-surface profile for Westerly Creek is not impacted by the revision to this reach of Sand Creek.

This revision is shown on Flood Insurance Rate Map Panels 0006 and 0012. Profile Panels 80P, 81P, and 82P, Table 1, "Flooding Sources Studied by Detailed Methods," Table 2, "Summary of Discharges," and Table 3, "Floodway Data," were revised and Profile Panels 97P and 98P were added to the Flood Insurance Study report as part of this revision.

10.4 Fourth Revision

This study was revised on September 7, 1998, to incorporate a Letter of Map Revision (LOMR) dated April 16, 1996, for Westerly Creek. The LOMR was based on more detailed hydrologic and hydraulic analyses that reflected the effects of the Westerly Creek Dam and channel improvements along Westerly Creek. The revised analyses were performed by Merrick & Company and affect the reach of Westerly Creek from just upstream of the Kelly Road Dam to Havana Street, which is in the area that was formerly Lowry Air Force Base. This reach was previously studied by approximate methods and designated Zone A on the Flood Insurance Rate Map. The reach of Westerly Creek from approximately 1,350 feet downstream of Havana Street to Havana Street lies outside the City and County of Denver within the corporate limits of the City of Aurora, Colorado.

The revised hydrologic analysis was performed using the Colorado Urban Hydrograph Procedure (Reference 40). The EPA Storm Water Management Model (Reference 37) was used for hydrograph routing.

The revised hydraulic analyses were performed using the U.S. Army Corps of Engineers (USACE) HEC-2 computer program (Reference 46). Revised cross-section data and the effects of the Westerly Creek Dam were incorporated into the hydraulic model. The results of the hydraulic model indicate that flow splits from the main channel of Westerly Creek downstream of Havana Street. This split flow, designated as Westerly Creek Overflow, rejoins Westerly Creek just upstream of the Westerly Creek Dam. The hydraulic model also shows that the 100-year flood is contained in an underground pipe from the Westerly Creek Dam to approximately 700 feet upstream of Lowry Boulevard.

Floodplain boundaries were delineated using topographic maps at a scale of 1:3,600, with a contour interval of 2 feet (Reference 107).

This revision is shown on Flood Insurance Rate Map Panels 0012 and 0016. Table 2, "Summary of Discharges," and Table 3, "Floodway Data," have been revised for Westerly Creek and Profile Panels 97P, 98P, and 99P for Westerly Creek and Profile Panels 102P and 103P for Westerly Creek Overflow have been added to reflect the results of the revised hydrologic and hydraulic analyses. In addition, the profile panels for Sand Creek Overflow have been renumbered as 100P and 101P due to the addition of panels for Westerly Creek.

This study was also revised to incorporate a LOMR dated January 8, 1997, that revised the BFEs and floodplain boundaries along Goldsmith Gulch, South Monaco Street Parkway Overflow, Cherry Creek, and Southmoor Park Tributary. The floodway boundaries along Goldsmith Gulch and South Monaco Street Parkway were also modified as part of the LOMR. This revision supersedes the results discussed in Section 10.1.

The modifications to the BFES and floodplain boundaries along the aforementioned flooding sources are a result of the construction of Phase III of the Goldsmith Gulch Flood Control Project. Phase III of this project includes construction of the Florida-South Monaco Street Parkway Storm Sewer System, channel and culvert construction and improvements, construction of an earthen berm at Bible Park, and construction of a detention pond at the corner of Iliff Avenue and South Monaco Street Parkway. The improvements affect the reach of Goldsmith Gulch from its confluence with Cherry Creek to just upstream of Belleview Avenue.

The construction of the Goldsmith Gulch Flood Control Project has created two distinct flow paths for Goldsmith Gulch downstream of Iliff Avenue: overland and street flow along South Monaco Street Parkway and flow contained within the channels and culverts of the existing Goldsmith Gulch flow path. The overland and street flow down South Monaco Street Parkway has been renamed the South Monaco Street Parkway Overflow.

The hydrologic analysis along Goldsmith Gulch was revised to account for the construction of the detention pond and improvements to existing detention facilities. The UDFCD Colorado Urban Hydrograph Procedure computer program (Reference 108) was used to generate the hydrographs for each subbasin in the watershed and the UDFCD Urban Drainage Storm Water Management computer model (Reference 109) was used to route the hydrographs through Goldsmith Gulch main channel and the Bible Park detention pond. The hydrologic analysis was performed by Sellards & Grigg, Inc. (Reference 110). The revised hydrologic analysis along Goldsmith Gulch also affects the flood discharges for Cherry Creek downstream of the confluence of Goldsmith Gulch. The flow from Goldsmith Gulch represents a large portion of the total flow in Cherry Creek downstream of the confluence, resulting in a reduction in the base flood discharges along Cherry Creek from the confluence point of Goldsmith Gulch to its confluence with the South Platte River. Revisions to the flood hazard information along this reach of Cherry Creek were beyond the scope of work of the LOMR. However, the effects of the reduced discharges along Cherry Creek were evaluated from approximately 50 feet upstream of South Holly Street to approximately 1,900 feet upstream of South Monaco Street Parkway to determine the impact of the revised discharge on backwater flooding from Cherry Creek in the vicinity of Minnesota Drive. The revised hydrologic analysis for Cherry Creek was performed by Michael Baker Jr., Inc. (Reference 111).

The hydraulic analyses along Goldsmith Gulch and South Monaco Street Parkway Overflow were performed by Sellards & Grigg, Inc. (Reference 110) using the USACE HEC-2 computer program (Reference 46), the Inter-Connected Pond Routing (ICPR) computer program (Reference 112), and hand computations. The ICPR computer program was used to determine inflow and outflow characteristics of the Iliff detention pond. Hand computations were used to determine the culvert headwater elevations and street flows.

As a result of the construction of the project, the BFEs for Goldsmith Gulch increased in some areas and decreased in others and the widths of the SFHA and the regulatory floodway increased in some areas and decreased in others. The BFEs along South Monaco Street Parkway have decreased. The widths of the SFHA and regulatory floodway increased and decreased throughout the revised reach. The reduction in the base flood discharge resulted in decreases in the BFEs along the revised reach of Cherry Creek. The width of the SFHA along Cherry Creek from approximately 50 feet upstream to approximately 1,200 feet upstream of South Holly Street decreased, where backwater from Cherry Creek affects the area in the vicinity of Minnesota Drive.

The modifications are shown on Flood Insurance Rate Map Panels 0019, 0020, 0024, and 0025 and Profile Panels 10P, 11P, 53P, 54P, 58P, and 99P through 107P and in Table 2, "Summary of Discharges," and Table 3, "Floodway Data." Profile Panels 99P through 107P replace Profile Panels 48P through 52P. Panels 53P, 54P, and 55P for Southmoor Park Tributary were revised to reflect the revised BFEs along Goldsmith Gulch and to correct measurement in the profile baseline. The base flood profile along the reach of Southmoor Park Tributary from its confluence with Goldsmith Gulch to Eastman Avenue has been deleted. The BFEs in this portion of Southmoor Park Tributary are controlled by Goldsmith Gulch.

10.5 Fifth Revision

This study was revised on November 17, 2005 to incorporate the Digital Flood Insurance Rate Map (DFIRM) conversion for the City and County of Denver.

This revision was completed by the Urban Drainage and Flood Control District (UDFCD) under FEMA Grant No. EMD-2003-GR-0381. UDFCD contracted Merrick and Company, a Geographic Information System consultant, to digitize the flood data from various sources, to prepare the data in conformance with FEMA's DFIRM specifications, and to layout the individual DFIRM panels.

Flood information used for the DFIRM conversion came from four sources. The first source was the UDFCD's own Flood Hazard Area Delineation studies. The second source was the work maps from the original Flood Insurance Study (FIS). The third source was the work maps from several Letters of Map Revision (LOMRs). There was one instance in which the work maps for the Goldsmith Gulch LOMR could not be located. In that case the UDFCD utilized the LOMR profiles and floodway data table to plot the floodplain and floodway boundaries on recent Denver topographic mapping. The fourth source was the City and County of Denver, which provided updated approximate floodplains for Second Creek and Third Creek at Denver International Airport.

For this revision, all elevations are referenced to North American Vertical Datum of 1988 (NAVD). A datum conversion value of 3.0' was determined to convert to NAVD (NGVD 29 +2.97' = NAVD 88. Elevation Reverence Marks (ERMs) shown on the FIRM represent those used during the preparation of this FIS. The elevations associated with each ERM were obtained and/or developed during FIS production to establish vertical control for determination of flood elevations and floodplain boundaries shown on the FIRM. Users should be aware that these ERM elevations may have changed since the publication of this FIS report. To obtain up-to-date elevation information on National Geodetic Survey (NGS) ERMS shown on this map, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov. Map users should seek verification of non-NGS ERM monument elevations when using these elevations for construction or floodplain management purposes.

The National Flood Insurance Program encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 100-year floodplain data, which may include a combination of the following: 10-, 50-, 100-, and 500-year flood elevations; delineations of the 100-year and 500-year floodplains; and 100-year floodway. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, the Floodway Data Table and the Summary of Discharges Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

Table 3, "Floodway Data" was revised to convert elevations to NAVD88. Profiles 1P through 119P were converted to NAVD88.

10.6 Sixth Revision

This study was revised on November 20, 2013 to incorporate new hydraulic study data and recent Letters of Map Revision (LOMRs).

This revision was completed by the UDFCD under its May 17, 1999 agreement with FEMA, entitled “Cooperating Technical Partners Mapping Activity Statement No. 21.” The final community meeting was held May 29, 2012 at the City and County of Denver Wastewater Management Division offices. UDFCD contracted ICON Engineering, Inc., to incorporate the flood hazard data from various sources, to prepare the data in conformance with FEMA's DFIRM specifications, and to produce the revised DFIRM panels. Specifically, a regulatory 1-foot rise floodway was added to the South Platte River flood hazard area. A corresponding floodway data table for the South Platte River was also added. Second, a new study for First Creek and First Creek Tributary T was incorporated into the countywide flood hazards. This replaced an existing approximate flood zone with a full detailed Zone AE flood zone and added Flood Insurance Study profiles and floodway data tables. Third, a short reach of Cherry Creek was redelineated from Confluence Park to approximately Arapahoe Street based upon the most recent topography. Finally, several LOMRs that were effective since November 2005 were incorporated into the revised DFIRM panels.

The South Platte River regulatory floodway was added based upon the 1-foot rise floodway developed as part of the original Flood Hazard Area Delineation (FHAD) study for the South Platte River (Reference 7). There is no revision to the floodplain delineations, only the addition of the floodway delineation and associated floodway data table.

The First Creek and First Creek Tributary T hydraulic study was completed by Moser and Associates in August 2010. The study updates a previous Zone A delineation for the flood sources to reflect development of the tributary drainage basins. The Zone AE delineation updates panels 0116H, 0117H, 0136H, and 0138H. The study added First Creek and First Creek Tributary T floodway data tables. First Creek profile panels 024P-028P and First Creek Tributary T panels 029P-031P were also added. This study supersedes LOMR Case Number 09-08-0058P, which was issued December 29, 2008.

The Cherry Creek redelineation was based on best available topographic data to correct a known alignment issue between the previous delineation and the constructed channel. The 2008 USGS 2-foot contours were utilized to correctly align the existing delineation with the constructed channel. This work was a shift of the existing delineation; no substantial changes to the top width of the floodplain were intended.

The following Letters of Map Revision (LOMRs) were incorporated into this revision. These cases went effective since the last revision and were incorporated into the respective DFIRM panels, FIS profiles, Summary of Discharges Tables, and Floodway Data Tables for clarity and consistency.

The LOMR issued November 18, 2005 revised the FIRM to show the effects of construction of the Invesco Field stadium. Revisions occurred along the South Platte River from Interstate Highway 25 to Colfax Avenue and along Sloans Lake Overflow from the confluence with the South Platte River to Federal Boulevard. There was no revision to the FIS report.

The LOMR issued December 9, 2008 revised the FIRM and FIS Profile and Summary of Discharges Table to reflect channel relocation and modifications along Westerly Creek from just upstream of the Kelly Road Dam to approximately 1,440 feet upstream of East Lowry Boulevard. A new flood source, Westerly Creek Tributary, was added to reflect the remaining flooding in the original Westerly Creek channel alignment.

The LOMR issued December 24, 2008 revised the FIRM to reflect the placement of fill within the regulatory floodway and the replacement and realignment of a culvert beneath Hampden Avenue along Southmoor Park Tributary. Revisions to the SFHA, shaded Zone X, and regulatory floodway occurred along Southmoor Park Tributary from just upstream of East Hampden Avenue to approximately 270 feet upstream. There were no changes in BFE, to hydrology, or to lettered hydraulic cross sections. Therefore, there were no revisions to the FIS report.

The LOMR issued December 29, 2008 revised the FIRM to reflect new topographic data along First Creek from approximately 5,210 feet downstream of East 48th

Avenue to approximately 4,520 feet upstream and along First Creek Tributary T from approximately 960 feet downstream of North Orleans Street to approximately 4,290 feet upstream. There were no revisions to the FIS report. This LOMR has been superseded in this revision of the FIS report by the First Creek and First Creek Tributary T hydraulic study by Moser and Associates dated August 2010.

The LOMR issued March 23, 2009 impacted Cherry Creek within Arapahoe County only but was shown as affecting the City and County of Denver because the shared community boundary with Denver was incorrectly shown on the previous FIRM and FIS for Arapahoe County. The Arapahoe County DFIRM and FIS which became effective on December 17, 2010, incorporated the full extent of this LOMR.

The LOMR issued June 23, 2009 revised the FIRM and FIS profile to reflect changes along Westerly Creek Pond and Westerly Creek Overflow, associated with improvements to the Common Ground Golf Course. Modifications occurred along Westerly Creek Pond from approximately 120 feet upstream of the confluence with Westerly Creek to approximately 1,120 feet upstream, and along Westerly Creek Overflow from the confluence with Westerly Creek Pond to approximately 1,690 feet downstream of North Havana Street.

The LOMR issued February 12, 2010 revised the FIRM and FIS report to reflect new topographical data and a new hydraulic study in the old Stapleton Airport area along Sand Creek from approximately 130 feet downstream of Quebec Street to approximately 350 feet upstream of Havana Street, along Westerly Creek from the confluence with Sand Creek to approximately 440 feet downstream of the Sand Creek Trail Bridge (within the backwater from Sand Creek), and along Sand Creek Overflow from the confluence with Sand Creek to approximately 1,990 feet upstream. The hydraulic analysis identified an additional split flow path, added to the FIRM and FIS as Sand Creek Smith Road Overflow, from the confluence with Sand Creek to approximately 3,630 feet upstream.

The LOMR issued February 12, 2010 revised the FIRM and FIS report to reflect the certification of a levee and floodwall system and the construction of channel improvements along the South Platte River from approximately 2,530 feet downstream of Franklin Street to approximately 1,380 feet upstream of 31st Street and along the South Platte River (Franklin Street Overflow) from approximately 1,990 feet downstream to the divergence from the South Platte River. The old South Platte River (West Bank Split Flow) was renamed South Platte River (Franklin Street Overflow) because of a change to the spill location and the elimination of 1% annual chance flooding from much of the overflow due to the levee and floodwall system.

The LOMR issued October 5, 2012 revised the FIRM and FIS report to reflect the construction of the new Central Park Boulevard roadway and bridge over Interstate Highway 70 and highway ramps and bridges for the I-70, State Highway 270, and Central Park Boulevard interchange; water quality and detention ponds; removal of the old Stapleton Airport bridge over I-70; channelization and relocation of Sand Creek Overflow; and changes to the Zone X shaded boundary along Sand Creek Smith Road Overflow.

The LOMR issued December 17, 2012 revised the FIRM and FIS report to reflect the construction of the Central Park Boulevard bridge over Sand Creek and extension of the roadway south from Interstate Highway 70.

The LOMR issued December 17, 2012 revised the FIRM and FIS report to reflect the construction of a RTD light-rail bridge and channel improvements along the South Platte River from approximately 320 feet downstream of North Speer Boulevard to approximately 500 feet upstream of West 3rd Avenue and the resulting impacts to Lakewood Gulch, Lakewood Gulch Overflow, and Weir Gulch, which are tributary and confluence with the South Platte River within the revised reach. The South Platte River East Bank Split Flow was removed due to channelization of the South Platte River.

The LOMR issued August 9, 2013 revised the FIRM and FIS report to reflect the replacement of the existing 47th Avenue bridge crossing over Sand Creek with a new bridge having adequate hydraulic capacity and freeboard during the 1-percent-annual-chance flood.

The National Flood Insurance Program encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 100-year floodplain data, which may include a combination of the following: 10-, 50-, 100-, and 500-year flood elevations; delineations of the 100-year and 500-year floodplains; and 100-year floodway. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, the Floodway Data Table and the Summary of Discharges Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

10.7 Seventh Revision

This study was revised on ___________________________, to incorporate the Flood Hazard Area Delineation Reports from UDFCD as described below.

The UDFCD published a Flood Hazard Area Delineation Report (Reference 114) for Dutch Creek, Coon Creek, Lilley Gulch and Three Lakes Tributary in March 2008. The analysis was conducted by PBS&J, and identified flood hazard information on the above stream reaches. This report was incorporated into this revision of the FIS and DFIRM for portions of Coon Creek.

a. Acknowledgments

The Dutch Creek, Coon Creek and Three Lakes Tributary study flow path through the Arapahoe County, Colorado were performed by PBS&J. for the UDFCD as part of the "Flood Hazard Area Delineation Dutch Creek, Coon Creek, Lilley Gulch, and Three Lakes Tributary,".

FEMA reviewed and accepted these data for the purposes of this revision (Pending).

b. Scope

Detailed hydrologic and hydraulic analyses were conducted for this portion of Coon Creek. This portion of Coon Creek is approximately 2,900 feet long.

c. Hydrology

For the Coon Creek study, Peak discharges for the 0.2-, 1-, 2, and 10-percent-annual-chance of occurrence events were analyzed using the Colorado Urban Hydrograph Procedure (CUHP 2005), version 1.3.3, to generate hydrographs for each subwatershed. Hydrographs for the subwatersheds were routed using the Environmental Protection Agency Stormwater Management Model (EPA SWMM), version 5.0, to determine peak discharge rates at selected design points. The EPA SWMM results were then compared to watersheds of similar size and imperviousness.

d. Hydraulic

For the Coon Creek study, the U.S. Army Corps of Engineer's step backwater program HEC-RAS, Version 3.1.3, was used for the floodplain analysis of the drainage way. Cross sections used by the HEC-RAS model were developed from the digital elevation model (DEM) developed from the breakline survey file provided by UDFCD under separate survey contract. Bridges and culverts were individually surveyed or measured in the field.

A steady flow analysis was utilized to determine the flood profiles for the 0.2-, 1-, 2, and 10-percent-annual-chance storm events. Flow change locations were established at critical design points where there are significant changes in hydrology as determined by the EPA SWMM model. Between flow change locations, steady flow is maintained for defined channel segments along the reach.

e. Manning

For the Coon Creek study, estimates of channel and overbank roughness were made from aerial photographs and field observations. Manning's 'n' values ranged from 0.03 to 0.045 in the channel and from 0.03 to 0.08 in the overbank areas. Blocked obstructions and ineffective flow were utilized to account for large structures and flow conveyance paths.

Summary of peak discharges for Coon Creek in this revision are displayed below.

Flooding Source/Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Coon Creek					
At County Boundary	--[1]	924	1,616	2,012	3,703
Apporximately 570 feet upstream of Highway 121	--[1]	983	1,731	2,136	2,859

[1] Data not available

APPENDIX A

Figure 3. FIRM Notes to Users

NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products, or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Map Service Center at the number listed above.

To determine if flood insurance is available in the community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

The map is for use in administering the NFIP. It may not identify all areas subject to flooding, particularly from local drainage sources of small size. Consult the community map repository to find updated or additional flood hazard information.

BASE FLOOD ELEVATIONS: For more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined, consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations and/or Transect Data tables within this FIS Report. Use the flood elevation data within the FIS Report in conjunction with the FIRM for construction and/or floodplain management.

Coastal Base Flood Elevations shown on the map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Coastal flood elevations are also provided in the Summary of Stillwater Elevations table and Transect Data table in the FIS Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table and Transect Data table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on the FIRM.

FLOODWAY INFORMATION: Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the FIS Report for this jurisdiction.

FLOOD CONTROL STRUCTURE INFORMATION: Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to the "Flood Protection Measures" section of this FIS Report for information on flood control structures for this jurisdiction.

PROJECTION INFORMATION: The projection used in the preparation of the map was

Universal Transverse Mercator (UTM) Zone 10. The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

ELEVATION DATUM: Flood elevations on the FIRM are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

Local vertical monuments may have been used to create the map. To obtain current monument information, please contact the appropriate local community listed on the FIRM Index.

BASE MAP INFORMATION: Base map information shown on the FIRM was provided in digital format by the City and County of Denver, Department of Public works Geographic Information Systems (GIS) division dated 2015.

The map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables may reflect stream channel distances that differ from what is shown on the map.

Corporate limits shown on the map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after the map was published, map users should contact appropriate community officials to verify current corporate limit locations.

NOTES FOR FIRM INDEX

REVISIONS TO INDEX: As new studies are performed and FIRM panels are updated within Denver County, Colorado, corresponding revisions to the FIRM Index will be incorporated within the FIS Report to reflect the effective dates of those panels. Please refer to the FIRM Index to determine the most recent FIRM revision date for each community. The most recent FIRM panel effective date will correspond to the most recent index date.

ATTENTION: The corporate limits shown on this FIRM Index are based on the best information available at the time of publication. As such, they may be more current than those shown on FIRM panels issued before [*most recent FIRM panel date*].

SPECIAL NOTES FOR SPECIFIC FIRM PANELS

This Notes to Users section was created specifically for City and County of Denver, CO.

ACCREDITED LEVEE: Check with your local community to obtain more information, such as the estimated level of protection provided (which may exceed the 1-percent-annual-chance level) and Emergency Action Plan, on the levee system(s) shown as providing protection for areas on this panel. To mitigate flood risk in residual risk areas, property owners and residents are encouraged to consider flood insurance and floodproofing or other protective measures. For more information on flood insurance, interested parties should visit the FEMA Website at http://www.fema.gov/national-flood-insurance-program.

FLOOD RISK REPORT: A Flood Risk Report (FRR) may be available for many of the flooding sources and communities referenced in this FIS Report. The FRR is provided to increase public awareness of flood risk by helping communities identify the areas within their jurisdictions that have the greatest risks. Although non-regulatory, the information provided within the FRR can assist communities in assessing and evaluating mitigation opportunities to reduce these risks. It can also be used by communities developing or updating flood risk mitigation plans. These plans allow communities to identify and evaluate opportunities to reduce potential loss of life and property. However, the FRR is not intended to be the final authoritative source of all flood risk data for a project area; rather, it should be used with other data sources to paint a comprehensive picture of flood risk.

Figure 4. Map Legend for FIRM

SPECIAL FLOOD HAZARD AREAS: *The 1% annual chance flood, also known as the base flood or 100-year flood, has a 1% chance of happening or being exceeded each year. Special Flood Hazard Areas are subject to flooding by the 1% annual chance flood. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights. See note for specific types. If the floodway is too narrow to be shown, a note is shown.*

	Special Flood Hazard Areas subject to inundation by the 1% annual chance flood (Zones A, AE, AH, AO, AR, A99, V and VE)
Zone A	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. No base (1% annual chance) flood elevations (BFEs) or depths are shown within this zone.
Zone AE	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. Base flood elevations derived from the hydraulic analyses are shown within this zone.
Zone AH	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the hydraulic analyses are shown at selected intervals within this zone.

Zone AO	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the hydraulic analyses are shown within this zone.
Zone AR	The flood insurance rate zone that corresponds to areas that were formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
Zone A99	The flood insurance rate zone that corresponds to areas of the 1% annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or flood depths are shown within this zone.
Zone V	The flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not shown within this zone.
Zone VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the coastal analyses are shown within this zone as static whole-foot elevations that apply throughout the zone.
	Regulatory Floodway determined in Zone AE.

OTHER AREAS OF FLOOD HAZARD

	Shaded Zone X: Areas of 0.2% annual chance flood hazards and areas of 1% annual chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile.
	Future Conditions 1% Annual Chance Flood Hazard – Zone X: The flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined based on future-conditions hydrology. No base flood elevations or flood depths are shown within this zone.
	Area with Reduced Flood Risk due to Levee: Areas where an accredited levee, dike, or other flood control structure has reduced the flood risk from the 1% annual chance flood. See Notes to Users for important information.

OTHER AREAS

	Zone D (Areas of Undetermined Flood Hazard): The flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.
NO	Unshaded Zone X: Areas of minimal flood hazard.

FLOOD HAZARD AND OTHER BOUNDARY LINES	
(ortho) (vector)	Flood Zone Boundary (white line on ortho-photography-based mapping; gray line on vector-based mapping)
	Limit of Study
	Jurisdiction Boundary
	Limit of Moderate Wave Action (LiMWA): Indicates the inland limit of the area affected by waves greater than 1.5 feet
GENERAL STRUCTURES	
Aqueduct *Channel* *Culvert* *Storm Sewer*	Channel, Culvert, Aqueduct, or Storm Sewer
Dam *Jetty* *Weir*	Dam, Jetty, Weir
	Levee, Dike, or Floodwall
Bridge	Bridge
COASTAL BARRIER RESOURCES SYSTEM (CBRS) AND OTHERWISE PROTECTED AREAS (OPA): *CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas. See Notes to Users for important information.*	
CBRS AREA **09/30/2009**	Coastal Barrier Resources System Area: Labels are shown to clarify where this area shares a boundary with an incorporated area or overlaps with the floodway.

O **THERWISE PROTECTED** **AREA** **09/30/2009**	Otherwise Protected Area
REFERENCE MARKERS	
22.0	River mile Markers
CROSS SECTION & TRANSECT INFORMATION	
B 20.2	Lettered Cross Section with Regulatory Water Surface Elevation (BFE)
5280 21.1	Numbered Cross Section with Regulatory Water Surface Elevation (BFE)
17.5	Unlettered Cross Section with Regulatory Water Surface Elevation (BFE)
8	Coastal Transect
	Profile Baseline: Indicates the modeled flow path of a stream and is shown on FIRM panels for all valid studies with profiles or otherwise established base flood elevation.
	Coastal Transect Baseline: Used in the coastal flood hazard model to represent the 0.0-foot elevation contour and the starting point for the transect and the measuring point for the coastal mapping.
513	Base Flood Elevation Line
ZONE AE **(EL 16)**	Static Base Flood Elevation value (shown under zone label)
ZONE AO **(DEPTH 2)**	Zone designation with Depth
ZONE AO **(DEPTH 2)** **(VEL 15 FPS)**	Zone designation with Depth and Velocity
BASE MAP FEATURES	
Missouri Creek	River, Stream or Other Hydrographic Feature
234	Interstate Highway

234	U.S. Highway
234	State Highway
234	County Highway
MAPLE LANE	Street, Road, Avenue Name, or Private Drive if shown on Flood Profile
RAILROAD	Railroad
	Horizontal Reference Grid Line
—	Horizontal Reference Grid Ticks
+	Secondary Grid Crosshairs
Land Grant	Name of Land Grant
7	Section Number
R. 43 W. T. 22 N.	Range, Township Number
$^{42}\mathbf{76}^{\mathbf{000m}}\mathbf{E}$	Horizontal Reference Grid Coordinates (UTM)
365000 FT	Horizontal Reference Grid Coordinates (State Plane)
80° 16’ 52.5”	Corner Coordinates (Latitude, Longitude)